Final Draft

IL&FS | Environment

TECHNICAL EIA GUIDANCE MANUAL

FOR

OFFSHORE AND ONSHORE OIL & GAS EXPLORATION, DEVELOPMENT AND PRODUCTION

Prepared for

Ministry of Environment and Forests
Government of India

by

IL&FS Ecosmart Limited

Hyderabad

September 2009

PROJECT TEAM

Project Coordination **Ministry of Environment & Forests**	**Dr. (Mrs.) Nalini Bhat** Advisor, Ministry of Environment and Forests **Dr. (Mrs.) T. Chandni** Director, Ministry of Environment and Forests
Core Project Coordination Team **IL&FS Environment**	**Mr. Mahesh Babu** CEO **Mr. N. Sateesh Babu** Vice President & Project Director **Mr. B.S.V. Pavan Gopal** Manager –Technical **Mr. Padmanabhachar. K** Environmental Engineer **Ms. Chaitanya Vangeti** GIS Engineer **Ms. Suman Benedicta Thomas** Technical Writer
Resource Person	**Dr. Y. R. Mehta** Former Director, Gas Authority of India Limited
Expert Core & Peer Committee **Chairman**	**Dr. V. Rajagopalan, IAS** Principal Secretary Government of Uttar Pradesh
Core Members	**Dr. R. K. Garg** Former Chairman, EIA Committee Ministry of Environment and Forests **Mr. Paritosh C. Tyagi** Former Chairman, Central Pollution Control Board **Prof. S.P. Gautam** Chairman, Central Pollution Control Board **Dr. Tapan Chakraborti** Director, National Environmental Engineering Research Institute **Mr. K. P. Nyati** Former Head, Environmental Policy, Confederation of Indian Industry **Dr. G.K. Pandey** Advisor, Ministry of Environment and Forests **Dr. (Mrs.) Nalini Bhat** Advisor, Ministry of Environment and Forests **Dr. G.V. Subramaniam** Advisor, Ministry of Environment and Forests **Dr. B. Sengupta** Former Member Secretary, Central Pollution Control Board **Dr. R. C. Trivedi** Former Scientist, Central Pollution Control Board
Peer Members	**Dr. Hosabettu** Former Director, Ministry of Environment and Forests **Dr. B. D. Ghosh** Director, Centre For High Technology
Member Convener	**Mr. N. Sateesh Babu** Project Director

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

AAQ	Ambient Air Quality
ADB	Asian Development Bank
APHA	American Public Health Association
B/C	Benefits Cost Ratio
BCM	Billion Cubic Metre
BIS	Bureau of Indian Standards
BOD	Biological oxygen demand
BOQ	Bill of Quantities
BOT	Built-Operate-Transfer
BLEVE	(Boiling Liquid Expanding Vapour Cloud) or Vapour Cloud Explosion
BPX	By Product Exchange
BTEX	Benzene, Ethyl benzene, Toluene, and Xylenes
CBM	Coal Bed Methane
CCA	Conventional Cost Accounting
CEA	Central Electricity Authority
CEAA	Canadian Environmental Assessment Agency
CER	Corporate environmental reports
CFE	Consent for Establishment
COD	Chemical Oxygen Demand
CP	Cleaner Production
CPCB	Central Pollution Control Board
CRZ	Coastal Regulatory Zone
CSR	Corporate Social Responsibility
CST	Central Sales Tax
DA	Development Authorities
DC	Drill cuttings
DfE	Design for Environment
DGH	Directorate General of Hydrocarbons
DO	Dissolved Oxygen
EAC	Expert Appraisal Committee
EBM	Environmental Baseline Monitoring
EcE	Economic-cum-Environmental
ECI	Environmental Condition Indicators
EHS	Environment Health and Safety
EIA	Environmental Impact Assessment
EIS	Environmental Information system

E&P	Exploration and Production
EPA	Environmental Protection Agency
EPI	Environmental performance indicators
EPR	Extended Producers Responsibilities
EMA	Environmental Management Accounting
EMS	Environmental Management System
EMP	Environmental Management Plan
ERPC	Environment Research and Protection Centre
ETP	Effluent Treatment Plant
FBP	Final Boiling Point
FCA	Full Cost Assessment
FE&TI	Fire-Explosion and Toxicity Index
FP	Flash Point
GEMS	Global Environmental Monitoring System
GGFR	Global Gas Flaring Reduction
GHF	General Hazard Factors
GHG	Green House Gas
GLC	Ground-level Concentration
GPH	General Process Hazards
GSPCL	Gujarat State Petrochemicals Ltd
H_2S	Hydrogen sulfide
HPI	Hydrocarbon Processing Industry
HTL	High Tide Line
IL&FS	Infrastructure Leasing and Financial Services
ILO	International Labour Organization
IMD	India Meteorological Department
INFOTERRA	Global Environmental Information Exchange Network of UNEP
IVI	Importance Value Index
ISO	International Standard Organization
JV	Joint Venture
LANDSAT	Land Remote Sensing Satellite / Land use Satellite
LDAR	Leak Detection and Repair
LCA	Life Cycle Assessment
LEL	Lower Explosive Limit
LNG	Liquefied Natural Gas
LTL	Low Tide Level
MCA	Maximum Credible Accident
MF	Material Factor
MFA	Material Flow Accounting

MMT	Million Metric Tonne
MODUs	Mobile Offshore Drilling Units
MoEF	Ministry of Environment & Forests
MP	Melting Point
MPNG	Ministry of Petroleum and Natural Gas
MRF	Material recovery facilities
MSES	Multi stage evaporator systems
MSW	Municipal Solid Waste
NADF	Non-Aqueous Drilling Fluids
NAQM	National Air Quality Monitoring
NDIR	Non-dispersive Infrared
NGO	Non-Government Organizations
NOAA	National Oceanic and Atmospheric Administration
NOC	No Objection Certificate
NORM	Naturally Occurring Radioactive Materials
OBM	Oil-base Mud
OCD	Offshore and Coastal Dispersion Model
OIL	Oil India Ltd
OISD	Oil Industry Safety Directorate
OSHA	Occupational Safety and Health Administration
PAH	Polycyclic Aromatic Hydrocarbons
P-CP	Programmatic Cleaner Production
P-EIA	Programmatic Environmental Impact Assessment
PCC	Pollution Control Committee
PCPIR	Petroleum, Chemicals & Petrochemical Investment Regions
POTW	Publicly owned treatment works
PPV	Peak Particle Velocity
R&D	Research and Development
R&R	Resettlement and Rehabilitation
RIL	Reliance India Ltd
RMF	Respective Material Factor
RPM	Respirable Particulate Matter
RSPM	Respirable Suspended Particulate Matter
ROW	right-of-way
QA/QC	Quality Assurance/Quality Control
QRA	Quantitative Risk Assessment
SBM	Synthetic Base Mud
SCADA	Supervisory Control and Data Acquisition System
SEAC	State Level Expert Appraisal Committee

SEIAA	State Level Environment Impact Assessment Authority
SEZ	Special Economic Zones
SPCB	State Pollution Control Board
SPHF	Special Process Hazard Factors
SPM	Suspended Particulate Matter
SS	Suspended Solids
TA	Technology Assessment
TCA	Total Cost Assessment
TDS	Total Dissolved Solids
TEQM	Total Environmental Quality Movement
TGM	Technical EIA Guidance Manual
TNO	Toegepast Naturweteshappelijk Onderzoek
TLV	Threshold Limit Value
TSDF	Treatment Storage Disposal Facility
TSS	Total Suspended Solids
UEL	Upper Explosive Limit
UNEP	United Nations Environmental Programme
USEPA	United States Environmental Protection Agency's
UT	Union Territory
UTEIAA	Union Territory Environment Impact Assessment Authority
UTPCC	Union Territory Pollution Control Committee
VOC	Volatile Organic Compounds
VEC	Valued Environmental Component
WB	World Bank Group / The World bank
WBCSD	World Business Council on Sustainable Development
WBDF	Water-based Drilling Fluids

ANNEXURES

Annexure I

A Compilation of Legal Instruments

Annexure II

Form 1 (Application Form for EIA Clearance)

Annexure III

Pre-feasibility Report

Annexure IV

Types of Monitoring and Network Design Considerations

Annexure V

Guidance for Assessment of Baseline Components and Attributes

Annexure VI

Sources of Secondary Data Collection

Annexure VII

Impact Prediction Models

1. INTRODUCTION TO THE TECHNICAL EIA GUIDANCE MANUALS PROJECT

Environmental Impact Assessment (EIA) is a process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made." These studies integrate the environmental concerns of developmental activities into the process of decision-making.

EIA has emerged as one of the successful policy innovations of the 20th Century in the process of ensuring sustained development. Today, EIA is formalized as a regulatory tool in more than 100 countries for effectively integration of environmental concerns in the economic development process. The EIA process in India was made mandatory and was also given a legislative status through a Notification issued in January 1994. The Notification, however, covered only a few selected industrial developmental activities. While there are subsequent amendments, this Notification issued on September 14, 2006 supersedes all the earlier Notifications, and has brought out structural changes in the clearance mechanism.

The basic tenets of this EIA Notification could be summarized into following:

- Pollution potential as the basis for prior Environmental Clearance based on pollution potential instead of investment criteria; and
- Decentralization of clearing powers to the State/Union Territory (UT) level Authorities for certain developmental activities to make the prior environmental clearance process quicker, transparent and effective mechanism of clearance.

Devolution of the power to grant clearances at the state-level for certain categories of the developmental activities / projects is a step forward to fulfill the basic tenets of the re-engineering *i.e.*, quicker, transparent and effective process but many issues come on its way of functional efficiency. These issues could be in technical and operational domains as listed below:

Technical issues

- Ensuring level playing ground to avoid arbitrariness in the decision-making process
- Classification of projects which do not require public hearing and detailed EIA (Category B2)
- Variations in drawing Terms of Reference (ToR) for EIA studies for a given developmental activity across the States/UTs
- Varying developmental-activity-specific expertise requirement for conducting EIA studies and their appraisal
- Availability of adequate sectoral experts and variations in competency levels
- Inadequate data verification, cross checking tools and supporting institutional framework

- Meeting time targets without compromising with the quality of assessments/ reviews
- Varying knowledge and skill levels of regulators, consultants and experts
- Newly added developmental activities for prior environmental clearance, *etc*.

Operational issues

- State level /UT level EIA Authorities (SEIAA/UTEIAA) are being formulated for the first time and many are functioning
- Varying roles and responsibilities of involved organizations
- Varying supporting institutional strengths across the States/UTs
- Varying manpower availability, *etc.*

1.1 Purpose

The purpose of developing the sector-specific technical EIA guidance manuals (TGM) is to provide clear and concise information on EIA to all the stakeholders *i.e*., the project proponent, the consultant, the reviewer, and the public. The TGMs are organized to cover following:

1. Conceptual facets of an EIA
2. Details on the developmental activity including environmental concerns and control technologies, *etc*.
3. Operational aspects; and
4. Roles and responsibilities of various organizations involved in the process of prior environmental clearance

For any given industry, each topic listed above could alone be the subject of a lengthy volume. However, in order to produce a manageable document, this project focuses on providing summary information for each topic. This format provides the reader with a synopsis of each issue. Text within each section was researched from many sources, and was usually condensed from more detailed sources pertaining to specific topics.

The contents of the document are designed with a view to facilitate in addressing the relevant technical and operational issues as mentioned in the earlier section. Besides, facilitates various stakeholders involved in the EIA clearance process *i.e.,*

- Project proponent will be fully aware of the procedures, common ToR for EIA studies, timelines, monitoring needs, *etc.*, in order to plan the projects/studies appropriately.
- The consultants across India will gain similar understanding about a given sector, and also the procedure for conducting the EIA studies, so that the quality of the EIA reports gets improved and streamlined.
- Reviewers across the States/UTs will have the same understanding about an industry sector and would able to draw a benchmark to establish the significant impacts for the purpose of prescribing the ToR for EIA studies and also in the process of review and appraisal.
- Public who are concerned about a new or expansion projects, can have access to this manual to know the manufacturing/production details, rejects/wastes from the operations, choice of cleaner/ control technologies, regulatory requirements, likely environmental and social concerns, mitigation measures, *etc.* in order to seek

clarifications appropriately in the process of public consultation. The procedural clarity in the document will further strengthen them to understand the stages involved in clearance and roles and responsibilities of various organizations.

- In addition, these manuals would substantially ease the pressure on reviewers at the scoping stage and would bring in functional efficiency at the central and state levels.

1.2 Project Implementation

The Ministry of Environment & Forests (MoEF), Government of India took up the task of developing sector-specific TGMs for all the developmental activities listed in the re-engineered EIA Notification. Infrastructure Leasing and Financial Services (IL&FS), Ecosmart Limited (Ecosmart), has been entrusted with the task of developing these manuals for 27 industrial and related sectors. Offshore and Onshore Oil and Gas Industry is one of these sectors, for which this manual is prepared.

The ability to design comprehensive EIA studies for specific industries depends on knowledge of several interrelated topics. Therefore, it requires expert inputs from multiple dimensions such as, administrative, project management, technical, scientific, social, economic risks *etc.*, in order to comprehensively analyze the issues of concern and to draw logical interpretations. Thus, Ecosmart has designed a well-composed implementation framework has been designed to factor inputs of the experts and stakeholders in the process of finalization of these manuals.

The process of manual preparation involved collection and collation of the secondary available information, technical review by sectoral resource persons and critical review and finalization by a competent Expert Committee composed of core and sectoral peer members.

The MoEF appreciates the efforts of Ecosmart, Expert Core and Peer Committee, resource persons and all those who have directly and indirectly contributed to this Manual.

1.3 Additional Information

This TGM is brought out by the MoEF to provide clarity to all the stakeholders involved in the 'prior environmental clearance' process. As such, the contents and clarifications given in this document do not withstand in case of a conflict with the statutory provisions of the Notifications and Executive Orders issued by the MoEF from time-to-time.

TGMs are not regulatory documents. Instead these are the tools designed to assist in successful completion of an EIA.

For the purposes of this project, the key elements considered under TGMs are: conceptual aspects of EIA; developmental activity-specific information; operational aspects; and roles and responsibilities of involved stakeholders.

This manual is prepared considering the Notification issued on September 14, 2006 and the updates. For recent updates, if any, may please refer the MoEF website *i.e.*, www.envfor.nic.in.

2. CONCEPTUAL FACETS OF EIA

2.1 Environment in EIA Context

'Environment' in EIA context mainly focuses, but is not limited to physical, chemical, biological, geological, social, economical, and aesthetic dimensions along with their complex interactions, which affects individuals, communities and ultimately determines their forms, character, relationship, and survival. In the EIA context, 'effect' and 'impact' can often be used interchangeably. However, 'impact' is considered as a value judgment of the significance of an effect.

Sustainable development is built on three basic premises *i.e.,* economic growth, ecological balance and social progress. Economic growth achieved in a way that does not consider, the environmental concerns, will not be sustainable in the long run. Therefore, sustainable development needs careful integration of environmental, economic, and social needs in order to achieve both an increased standard of living in short term, and a net gain or equilibrium among human, natural, and economic resources to support future generations in the long term.

"It is necessary to understand the links between environment and development in order to make choices for development that will be economically efficient, socially equitable and responsible, as well as environmentally sound." Agenda 21.

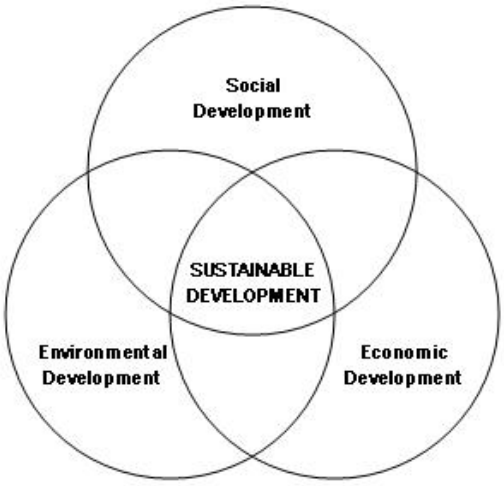


Figure 2-1: Inclusive Components of Sustainable Development

2.2 Pollution Control Strategy

Pollution control strategies can be broadly categorized into preventive and reactive. The reactive strategy refers to the steps that may be applied once the wastes are generated or contamination of receiving environment takes place. The control technology or a combination of technologies to minimize the impact due to the process rejects/wastes varies with quantity and characteristics, desired control efficiency and economics.

Many a number or combination of techniques could be adopted for treatment of a specific waste or the contaminated receiving environment, but are often judged based on techno-economic feasibility. Therefore, the best alternative is to take all possible steps to avoid pollution itself. This preventive approach refers to a hierarchy that involves: i) prevention & reduction; ii) recycling and re-use; iii) treatment; and iv) disposal, respectively.

Therefore, there is a need to shift the emphasis from the reactive to preventive strategy *i.e.,* to promote preventive environmental management. Preventive environmental management tools may be classified into following three groups:

Management Based Tools	Process Based Tools	Product Based Tools
Environmental management system (EMS)	Environmental technology assessment	Industrial ecology
Environmental performance evaluation	Toxic use reduction	Extended producers responsibility
Environmental audits	Best operating practices	Eco-labeling
Environmental reporting and communication	Environmentally best practice	Design for environment
Total cost accounting	Best available technology (BAT)	Life cycle assessment (LCA)
Law and policy	Waste minimization	
Trade and environment	Pollution prevention	
Environmental economics	Cleaner production	
	Cleaner technology	
	Eco-efficiency	

These tools are precisely discussed in next sections

2.3 Tools for Preventive Environmental Management

These tools preventive environmental management can be broadly classified into following three groups:

- Tools for assessment and analysis
- Tools for action; and
- Tools for communication

Specific tools under each group are discussed precisely in next sections.

2.3.1 Tools for assessment and analysis

2.3.1.1 Risk assessment

Risk is associated with the frequency of failure and consequence effect. Predicting such situations and evaluation of risk is essential to take appropriate preventive measures. The major concern of the assessment is to identify the activities falling in a matrix of high & low frequencies at which the failures occur and the degree of its impact. The high frequency, low impact activities can be managed by regular maintenance *i.e.*, LDAR (Leak detection and repair) programmes. Whereas, the low frequency, high impact activities are of major concern (accidents) in terms of risk assessment. As the frequency is low, often the required precautions are not realized or maintained. However, these risk assessment identify the areas of major concerns which require additional preventive

measures, likely consequence distances considering domino effects, which will give the possible casualties and ecological loss in case of accidents. These magnitudes demand the attention for preventive and disaster management plans (DMP). Thus is an essential tool to ensure safety of operations.

2.3.1.2 Life Cycle Assessment

A broader approach followed to deal with environmental impacts during manufacturing is called LCA. This approach recognizes that environmental concerns are associated with every step of the processing w.r.t. the manufacturing of products and also examines environmental impacts at all stages of the project life cycle. LCA includes the product design, development, manufacturing, packaging, distribution, usage and disposal. LCA is concerned with reducing environmental impacts at all these stages and considering the total picture rather than just one stage of the production process.

By availing this concept, firms minimize the costs incurred on the environmental conservation throughout the project life cycle. LCA also provides sufficient scope to think about cost-effective alternatives.

2.3.1.3 Total Cost Assessment

Total Cost Assessment (TCA) is an enhanced financial analysis tool that is used to assess the profitability of alternative courses of action ex. raw material substitution to reduce the costs of managing the wastes generated by process; an energy retrofit to reduce the costs of energy consumption. This is particularly relevant for pollution prevention options, because of their nature, often produce financial savings that are overlooked in conventional financial analysis, either because they are misallocated, uncertain, hard to quantify, or occur more than three to five years after the initial investment. TCA involves all of the relevant costs and savings associated with an option so that it can compete for scarce capital resources fairly, on a level playing field. The assessments are often beneficial in following:

- Identification of costly resource inefficiencies
- Financial analysis of environmental activities/projects such as investment in cleaner technologies
- Prioritization of environmental activities/projects
- Evaluation of products and product pricing
- Bench marking against the performance of other processes or against the competitors

A comparison of cost assessments is given below:

- Conventional cost accounting (CCA): Direct and indirect financial costs+ Recognized contingent costs
- Total cost assessment (TCA): A broader range of direct, indirect, contingent and less quantifiable costs
- Full cost assessment (FCA): TCA + External social costs borne by society

2.3.1.4 Environmental audit/statement

The key objectives of an environmental audit includes compliance verification, problem identification, environmental impact measurement, environmental performance measurement, conforming effectiveness of EMS, providing a database for corrective

actions and future actions, developing companies' environmental strategy, communication and formulating environmental policy.

The MoEF, Government of India issued Notification on 'Environmental Statements' (ES) in April, 1992 and further amended in April, 1993 - as per the notification, the industries are required to submit ES to the respective State Pollution Control Boards (SPCBs). ES is a pro-active tool for self-examination of the industry itself to reduce/minimize pollution by adopting process modifications, recycling and reusing of the resources. The regular submission of ES will indicate the systematic improvement in environmental pollution control being achieved by the industry. In other way, the specific points in ES may be used as environmental performance indicators for relative comparison, implementation and to promote better practices.

2.3.1.5 Environmental benchmarking

Environmental performance and operational indicators could be used to navigate, manage and communicate the significant aspects and give enough evidence of good environmental house keeping. Besides prescribing standards, an insight to identify the performance indicators and prescribing schedule for systematic improvement in performance of these indicators will yield better results.

Relative indicators may be identified for different industrial sectors to be integrated with the companies and organizations to monitor and manage the different environmental aspects of the company, to benchmark and compare two or more companies from the same sector. These could cover the water consumption, wastewater generation, energy consumption, solid/hazardous waste generation, chemical consumption, *etc*., per tonne of final product. Once these benchmarks are developed, the industries which are below them may be guided and enforced to reach the level and those which are better than the benchmark may be encouraged further by giving incentives, *etc*.

2.3.1.6 Environmental indicators

Indicators can be classified into environmental performance indicators (EPI) and environmental condition indicators (ECI). The EPIs can be further divided into two categories *i.e.* operational performance indicators and management performance indicators.

The operational performance indicators are related to the processes and other operational activities of the organization. These would typically address the issue of raw material consumption, energy consumption, water consumption in the industry, the quantities of wastewater generated, other solid wastes generated, emission from the industry, *etc*.

Management performance indicators, on the other hand, are related to the management efforts to influence the environmental performance of the organization's operations.

The environmental condition indicators provide information about the environment. These indicators provide information about the local, regional, national or global condition of the environment. This information helps the organization to understand the environmental impacts of its activities and thus helps in making decision to improve the environmental performance.

Indicators are basically used to evaluate environmental performance against the set standards and thus indicate the direction in which to proceed. Selection of type of indicators for a firm or project depends upon its relevance, clarity and realistic cost of collection and its development.

2.3.2 Tools for Action

2.3.2.1 Environmental Policy

An environmental policy is a statement of the organization's overall aim and principles of action w.r.t. the environment, including compliance with all relevant regulatory requirements. It is a key tool in communicating the environmental priorities of the organization to all its employees. To ensure an organization's commitment towards formulated environmental policy, it is essential for the top management be involved in the process of formulating the policy and setting priorities. Therefore, the first step is to get the commitment from the higher levels of management. The organization should then conduct an initial environmental review and draft an environmental policy. This draft should be discussed and approved by the board of directors and finally the approved environmental policy statement must be communicated internally among all its employees and must also be made available to the public.

2.3.2.2 Market-Based Economic Instruments

Market-based instruments are regulations that encourage behavior through market signals rather than through explicit directives regarding pollution control levels. These policy instruments such as tradable permits pollution charge are often described as harnessing market forces. Market-based instruments can be categorized into four major categories *i.e.*:

- **Pollution charge:** Charge system will assess a fee or tax on the amount of pollution a firm or source generates. It is worthwhile for the firm to reduce emissions to the point, where its marginal abatement costs are equal to the tax rate. Thus firms control pollution to different degrees *i.e.*, High cost controllers – less; low-cost controllers – more. The charge system encourages the industries to further reduce the pollutants. The charges thus collected can form a fund for restoration of the environment. Another form of pollution charge is a deposit refund system, where the consumers pay a surcharge when purchasing a potentially polluting product, and receive a refund on return of the product after useful life span at appropriate centers. The concept of extended producer's responsibility is brought in to avoid accumulation of dangerous products in the environment.
- **Tradable permits**: Under this system, firms that achieve the emission levels below their allotted level may sell the surplus permits. Similarly the firms, which are required to spend more to attain the required degree of treatment/allotted levels, can purchase permits from others at lower costs and may be benefited.
- **Market barrier reductions:** Three known market barrier reduction types are as follows:
  - Market creation: Measure and facilitate the voluntary exchange of water rights and thus promotes efficient allocation of scarce water supplies.
  - Liability concerns: Encourage firms to consider potential environmental damages of their decisions

- Information programmes: Ecolabeling and energy – efficiency product labeling requirements

- **Government Subsidy Reduction:** Subsidies are the mirror images of taxes and, in theory, can provide incentives to address environmental problems. However, it has been reported that the subsidies encourage economically in-efficient and environmentally un-sound practices, and often lead to market distortions due differences in the area. However, in the national interest, subsidies are important to sustain the expansion of production. In such cases, the subsidy may be comparable to the net social benefit.

2.3.2.3 Innovative funding mechanism

There are many forums under which the fund is made available for the issues which are of global/regional concern (GEF, OECD, Deutch green fund, *etc*.) *i.e*., climate change, basal convention and further fund sources are being explored for the persistent organic pollutants convention. Besides the global funding mechanism, there needs to be localized alternative mechanisms for boosting the investment in environmental pollution control. For example, in India the Government has established mechanism to fund the common effluent treatment plants (CETP), which are specifically serving the small and medium scale enterprises *i.e.,* 25% share by the State Government, matching grants from the Central Government and surety for 25% soft loan. It means that the industries need to invest only 25% initially, thus encouraging voluntary compliance.

There are some more options *i.e*. if the pollution tax/charge is imposed on the residual pollution being caused by the industries, municipalities, *etc*., fund will automatically be generated, which in turn, can be utilized for funding the environmental improvement programmes. The emerging concept of build-operate-transfer (BOT) is an encouraging development, where there is a possibility to generate revenue by application of advanced technologies. There are many opportunities, which can be explored. However, what is required is the paradigm shift and focused efforts.

2.3.2.4 EMS and ISO certification

EMS is that part of the overall management system, which includes the organizational structure, responsibilities, practices, procedures, processes and resources for determining and implementing the forms of overall aims, principles of action w.r.t. the environment. It encompasses the totality of organizational, administrative and policy provisions to be taken by a firm to control its environmental influences. Common elements of an EMS are the identification of the environmental impacts and legal obligations, the development of a plan for management & improvement, the assignment of the responsibilities and monitoring of the performance.

2.3.2.5 Total environment quality movement (TEQM)

Quality was regarded as

- A product attribute that must be set at an acceptable level and balanced against the cost
- Something delivered by technical systems engineered by experts rather than the organization as a whole

- Assured primarily through the findings and correction of mistakes at the end of the production process

One expression of the total environment quality movement (TEQM) is a system of control called Kaizen. The principles of Kaizen are:

- Goal must be continuous improvement of quality instead of acceptable quality
- Responsibility of the quality shall be shared by all members of an organization
- Efforts should be focused on improving the whole process and design of the products

With some modifications, the TQM approach can be applied in the improvement of corporate environmental performance in both process and product areas.

2.3.2.6 Eco-labeling

It is known as the practice of supplying information on the environmental characteristics of a product or service to the general public. These labeling schemes can be grouped into three types:

- Type I: Multiple criteria base; third party (Govt. or non-commercial private organizations) programme claims overall environmental preferability.
- Type II: Specific attributes of a product; often issued by a company/industrial association
- Type III: Agreed set of indices; provides quantified information; self declaration

Among the above, Type I are more reliable because they are established by a third-party and considers the environmental impacts of a product from cradle to grave. However, the labeling program will only be effective if linked with complementary programme of consumer education and up on restriction of umbrella claims by the producers.

2.3.2.7 Cleaner production

Cleaner production is one of the tools, which has lot of bearing on environmental pollution control. It is also seen that the approach is changing with time *i.e*. dumping-to-control-to-recycle-to-prevention. Promotion of cleaner production principles involves an insight into the production processes not only to get desired yield, but also to optimise on raw material consumption *i.e*. resource conservation and implications of the waste treatment and disposal.

2.3.2.8 4-R concept

The concept endorses utilization of waste as a by-product to the extent possible *i.e*., Recycle, Recover, Reuse, Recharge. Recycling refers to using wastes/ by-products in the process again as a raw material to maximize the production. Recovery refers to engineering means such as solvent extraction, distillation, precipitation, *etc*., to separate the useful constituents of the wastes, so that these recovered materials can be used. Reuse refers to utilization of waste from one process as a raw material to other. Recharging is an option in which the natural systems are used for renovation of waste for further use.

2.3.2.9 Eco-efficiency

The World Business Council on Sustainable Development (WBCSD) defines eco-efficiency as "the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle, to a level at least in line with earth's carrying capacity". The business implements the eco-efficiency on four levels *i.e.,* optimized processes, recycling of wastes, eco-innovation and new services. Fussler (1995) defined six dimensions of eco-efficiency, which are given below to understand/examine the system.

- **Mass:** There is an opportunity to significantly reduce mass burdens (raw materials, fuels, utilities consumed during the life cycle)
- **Reduce energy use:** The opportunity is to sport the parts of the system and life cycle, which have the highest energy intensity, and to redesign the product or its use to provide significant energy savings
- **Reduce environmental toxins:** This is a concern to the environmental quality and human health. In nature nothing is lost. The opportunity here is to significantly control the dispersion of toxic elements such as carbon, sulphur, mercury *etc*.
- **Recycle when practical:** Designing for recycling is important
- **Working with Mother Nature:** Materials are borrowed and returned to the nature without negatively affecting the balance of the cycle.
- **Make it last longer:** It relates to useful life and functions of products. Increasing the functionality of products also increases their eco-efficiency.

The competitiveness among the companies and long-term survival will continue and the successful implementation of eco-efficiency will contribute to their success. There is a need to shift towards responsible consumerism equal to the efficiency gains made by corporations – doing more with less.

2.3.2.10 Industrial ecosystem or metabolism

Eco-industrial development is a new paradigm for achieving excellence in business and environmental performance. It opens up innovative new avenues for managing business and conducting economic development by creating linkages among local 'resources', including businesses, non-profit groups, governments, unions, educational institutions, and communities for creative fostering of dynamic and responsible growth. Antiquated business strategies based on isolated enterprises are no longer responsive enough to market, environmental and community requirements.

Sustainable eco-industrial development has a systematic view of development, business and environment attempting to stretch the boundaries of current practice on one level, while it fosters right connections between the wastes and resources needed for production and at the other level. It is a whole new way of thinking about doing business and interacting with communities. At a most basic level, it is each organization seeking higher performance within itself. However, larger chunk of eco-industrial activity is moving to a new level by increasing the inter-connections between the companies.

Strategic partnership networked manufacturing and performed supplier arrangements are all the examples of ways used by the businesses to ensure growth, contain costs and to reach out for new opportunities.

For most businesses, the two essentials for success are the responsive markets and access to cost-effective, quality resources for developing products or delivering services. In absence of these two factors, every other incentive virtually becomes a minor consideration.

Transportation issues are important at two levels – the ability to get goods to market in an expeditious way is essential to success in this day of just-in-time inventories. The use of least impact transportation, with due consideration of speed and cost, supports business success and addresses the concerned in the community.

Eco-industrial development works because it consciously mixes a range of targeted strategies shaped to the contours of the local community. Most importantly, it works because the communities want nothing less than the best possible in or near their neighborhoods. For companies, it provides a path towards significant higher operating results and positive market presence. For our environment, it provides greater hope that the waste will be transformed into valued product and that the stewardship will be a joint pledge of both businesses and communities.

2.3.2.11 Voluntary Agreements

Voluntary environmental agreements among the industries, government, public representatives, NGOs and other concerned towards attaining certain future demands of the environment are reported to be successful. Such agreements may be used as a tool where Government would like to make the standards stringent in future (phase-wise-stringent). These may be used when conditions are temporary and requires timely replacements. Also these may be used as supplementary/complimentary in implementation of the regulation. The agreements may include:

- Target objectives (emission limit values/standards)
- Performance objectives (operating procedures)
- R&D activities – Government and industry may have agreement to establish better control technologies.
- Monitoring & reporting of the agreement conditions by other agents (NGOs, public participants, civil authority *etc*.,)

In India, the MoEF, has organized such programme, popularly known as the corporate responsibility for environment protection (CREP) considering identified 17 categories of high pollution potential industrial sectors. Publication in this regard, is available with Central Pollution Control Board (CPCB).

2.3.3 Tools for Communication

2.3.3.1 State of Environment

The Government of India brought out the state of environment report for entire country and similar reports available for many of the states. These reports are published at regular intervals to record trends and to identify the required interventions at various levels. These reports consider the internationally accepted DPSIR framework for the presentation of the information. DPSIR refers to

- D – Driving forces – causes of concern *i.e.* industries, transportation *etc*.
- P – Pressure – pollutants emanating from driving forces *i.e.* emission

- S – State – quality of environment *i.e.* air, water & soil quality
- I – Impact – Impact on health, eco-system, materials, biodiversity, economic damage *etc*.
- R – Responses – action for cleaner production, policies (including standards/guidelines), targets *etc*.

Environment reports including the above elements gives a comprehensive picture of a region/country in order to take appropriate measures for improvement. Such reports capture the concerns which could be considered in EIAs.

2.3.3.2 Corporate Environmental Reporting

Corporate Environmental Reports (CER) are just a form of environmental reporting defined as publicly available, stand-alone reports, issued voluntarily by the industries on their environmental activities (Borphy and starkey-1996). CER is a means to environmental improvement and greater accountability, not an end in itself.

Three categories of environmental disclosure are:

- Involuntary disclosure: Without its permission and against its will (env. Campaign, press *etc*.)
- Mandatory disclosure: As required by law
- Voluntary disclosure: The disclosure of information on a voluntary basis

2.4 Objectives of EIA

Objectives of EIA include the following:

- To ensure that the environmental considerations are explicitly addressed and incorporated into the development and decision-making process;
- To anticipate and avoid, minimize or offset the adverse significant biophysical, social and other relevant effects of development proposals;
- To protect the productivity and capacity of natural systems and the ecological processes which maintain their functions; and
- To promote development that is sustainable and optimizes resource use and management opportunities.

2.5 Types of EIA

Environmental assessments could be classified into four types *i.e.* strategic environmental assessment, regional EIA, sectoral EIA and project level EIA. These are precisely discussed below:

Strategic environmental assessment

Strategic environmental assessment (SEA) refers to systematic analysis of the environmental effects of development policies, plans, programmes and other proposed strategic actions. SEA represents a proactive approach to integrating environmental considerations into the higher levels of decision-making – beyond the project level, when major alternatives are still open.

Regional EIA

EIA in the context of regional planning integrates environmental concerns into development planning for a geographic region, normally at the sub-country level. Such an approach is referred to as the economic-cum-environmental (EcE) development planning (Asian Development Bank, 1993a). This approach facilitates adequate integration of economic development with management of renewable natural resources within the carrying capacity limitation to achieve sustainable development. It fulfils the need for macro-level environmental integration, which the project-oriented EIA is unable to address effectively. Regional EIA addresses the environmental impacts of regional development plans and thus, the context for project-level EIA of the subsequent projects, within the region. In addition, if environmental effects are considered at regional level, then the cumulative environmental effects of all the projects within the region can be accounted.

Sectoral EIA

Instead of project-level-EIA, an EIA should take place in the context of regional and sectoral level planning. Once sectoral level development plans have the integrated sectoral environmental concerns addressed, the scope of project-level EIA will be quite narrow. Sectoral EIA will help to address specific environmental problems that may be encountered in planning and implementing sectoral development projects.

Project level EIA

Project level EIA refers to the developmental activity in isolation and the impacts that it exerts on the receiving environment. Thus, it may not effectively integrate the cumulative effects of the development in a region.

From the above discussion, it is clear that the EIA shall be integrated at all levels *i.e.,* strategic, regional, sectoral and project level. Whereas, the strategic EIA is a structural change in the way the things are evaluated for decision-making, the regional EIA refers to substantial information processing and drawing complex inferences. The project-level EIA is relatively simple and reaches to meaningful conclusions. Therefore in India, largely, the project-level EIA studies are taking place and are being considered. However, in the re-engineered Notification, provisions are incorporated for giving a single clearance for the entire industrial estate for e.g., Leather parks, pharma cities, *etc*., which is a step towards the regional approach.

As we progress and the resource planning concepts emerge in our decision-making process, the integration of overall regional issues will become part of the impact assessment studies.

2.6 Basic EIA Principles

By integrating the environmental impacts of the development activities and their mitigation in early stages of project planning, the benefits of EIA could be realized in all stages of a project, from exploration and planning, through construction, operations, decommissioning, and beyond site closure.

A properly-conducted-EIA also lessens conflicts by promoting community participation, informing decision-makers, and also helps in laying the base for environmentally sound

projects. An EIA should meet at least three core values (EIA Training Resource Manual, UNEP 2002,):

- Integrity: The EIA process should be fair, objective, unbiased and balanced
- Utility: The EIA process should provide balanced, credible information for decision-making
- Sustainability: The EIA process should result in environmental safeguards

Ideally an EIA process should be:

- Purposive- should inform decision-makers and result in appropriate levels of environmental protection and community well-being.
- Rigorous- should apply 'best practicable' science, employing methodologies and techniques appropriate to address the problems being investigated.
- Practical- should result in providing information and acceptable and implementable solutions for problems faced by proponents.
- Relevant- should provide sufficient, reliable and usable information for development planning and decision-making.
- Cost-effective- should impose the minimum cost burdens in terms of time and finance on proponents and participants consistent with meeting accepted requirements and objectives of EIA.
- Efficient- should achieve the objectives of EIA within the limits of available information, time, resources and methodology.
- Focused- should concentrate on significant environmental effects and key issues; *i.e.,* the matters that need to be considered while making decisions.
- Adaptive- should be adjusted to the realities, issues and circumstances of the proposals under review without compromising the integrity of the process, and be iterative, incorporating lessons learnt throughout the project life cycle.
- Participative- should provide appropriate opportunities to inform and involve the interested and affected public, and their inputs and concerns should be addressed explicitly in the documentation and decision-making.
- Inter-disciplinary- should ensure that the appropriate techniques and experts in the relevant bio-physical and socio-economic disciplines are employed, including the use of traditional knowledge as relevant.
- Credible- should be carried out with professionalism, rigor, fairness, objectivity, impartiality and balance, and be subject to independent checks and verification.
- Integrated- should address the inter-relationships of social, economic and biophysical aspects.
- Transparent- should have clear, easily understood requirements for EIA content; ensure public access to information; identify the factors that are to be taken into account in decision-making; and acknowledge limitations and difficulties.
- Systematic- should result in full consideration of all relevant information on the affected environment, of proposed alternatives and their impacts, and of the measures necessary to monitor and investigate residual effects.

2.7 Project Cycle

The generic project cycle including that of Onshore and Offshore Oil and Gas industry has six main stages:

1) Project concept
2) Pre-feasibility
3) Feasibility
4) Design and engineering
5) Implementation
6) Monitoring and evaluation

It is important to consider the environmental factors on an equal basis with the technical and economic factors throughout the project planning, assessment and implementation phases. EIA should be introduced at the earliest in the project cycle and must be made an integral part of the project pre-feasibility and feasibility stage. If the EIA considerations are given due respect in the site selection process by the project proponent, the subsequent stages of the clearance process would get simplified and would also facilitate easy compliance to the mitigation measures through out the project life cycle.

A project's feasibility study should include a detailed assessment of significant impacts, the prediction and quantification of impacts and delineation of EMPs. Findings of the EIA study should preferably be incorporated in the project design stage so that the project as well as the site alternatives is studied and necessary changes, if required, are incorporated in the project design stage. This practice will also help the management in assessing the negative impacts and in designing cost-effective remedial measures. In general, EIA enhances the project quality and improves the project planning process.

2.8 Environmental Impacts

Environmental impacts resulting from proposed actions can be grouped into following categories:

- Beneficial or detrimental
- Naturally reversible or irreversible
- Repairable via management practices or irreparable
- Short-term or long-term
- Temporary or continuous
- Occurring during construction phase or operational phase
- Local, regional, national or global
- Accidental or planned (recognized before hand)
- Direct (primary) or Indirect (secondary)
- Cumulative or single

The category of impact as stated above and its significance will facilitate the Expert Appraisal Committee EACto take a view on the ToR for EIA studies, as well as, in decision making process about the developmental activity.

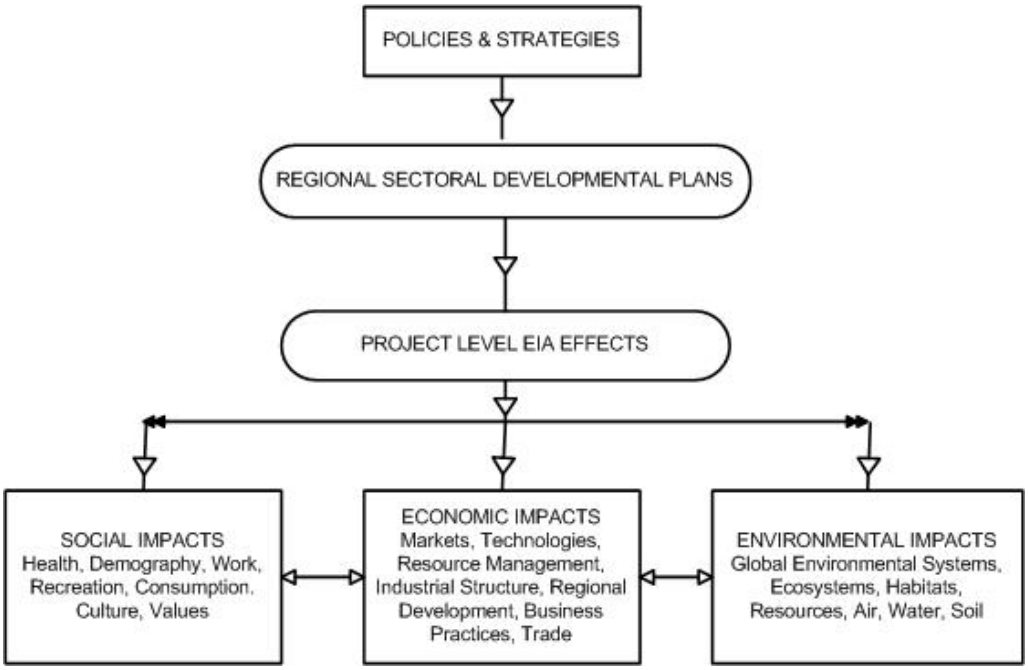


Figure 2-2: Types of Impacts

The nature of impacts could fall within three broad classifications *i.e.,* direct, indirect and cumulative, based on the characteristics of impacts. The assessment of direct, indirect and cumulative impacts should not be considered in isolation or considered as separate stages in the EIA. Ideally, the assessment of such impacts should form an integral part of all stages of the EIA. The TGM does not recommend a single method to assess the types of impacts, but suggests a practical framework/approach that can be adapted and combined to suit a particular project and the nature of impacts.

2.8.1 Direct impacts

Direct impacts occur through direct interaction of an activity with an environmental, social, or economic component. The oil and gas exploration and productions activities may contaminate the basic environmental media. For example, the discharge of wastewaters would directly impact the water and soil quality in the vicinity and finally the health of the workers.

2.8.2 Indirect impacts

Indirect impacts on the environment are those which are not a direct result of the project, often produced away from or as a result of a complex impact pathway. The indirect impacts are also known as secondary or even tertiary level impacts. An example of indirect impact, is the decline in water quality due to the discharge of wastewaters and other crude oils into the sea. This may, in turn, lead to a secondary indirect impact on aquatic flora in that water body and may not be any further fishing activities. Reduction in fishing harvests, affecting the incomes of fishermen is a third level impact. Such impacts are characterized as socio-economic (third level) impacts. The indirect impacts may also include growth-inducing impacts and other effects related to induced changes to the pattern of land use or additional road network, population density or growth rate. In the process, air, water and other natural systems including the ecosystem may also be affected.

2.8.3 Cumulative impacts

Cumulative impact consists of an impact that is created as a result of the combination of the project evaluated in the EIA together with other projects in the same vicinity causing related impacts. These impacts occur when the incremental impact of the project is combined with the cumulative effects of other past, present and reasonably foreseeable future projects. Figure 2-3 depicts the same. Respective EAC may exercise their discretion on a case-by-case basis for considering the cumulative impacts.

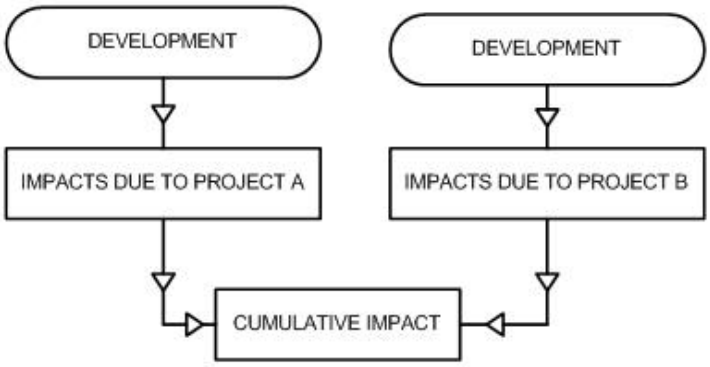


Figure 2-3: Cumulative Impact

2.8.4 Induced Impact

The cumulative impacts can be due to induced actions of projects and activities that may occur if the action under assessment is implemented such as growth-inducing impacts and other effects related to induced changes to the pattern of future land use or additional road network, population density or growth rate (e.g. excess growth may be induced in the zone of influence around a proposed industry, and in the process causing additional effects on air, water and other natural ecosystems). Induced actions may not be officially announced or be a part of any official plan. Increase in workforce and nearby communities contributes to this effect.

They usually have no direct relationship with the action under assessment, and represent the growth-inducing potential of an action. New roads leading from those constructed for a project, increased recreational activities (e.g., hunting, fishing), and construction of new service facilities are examples of induced actions.

However, the cumulative impacts due to induced development or third level or even secondary indirect impacts are difficult to be quantified. Because of higher levels of uncertainties, these impacts cannot normally be assessed over a long time horizon. An EIA practitioner can only guess as to what such induced impacts may be and the possible extent of their implications on the environmental factors. Respective expert appraisal committee may exercise their discretion on a case by case basis for considering the induced impacts.

2.9 Significance of Impacts

This TGM establishes the significance of impacts first and proceeds to delineate the associated mitigations and measures. So the significance here reflects the “worst-case-scenario” before mitigation is applied, and therefore provides an understanding of what

may happen if mitigation fails or if it is not as effective as predicted. For establishing significance of different impacts, understanding the responses and interaction of the environmental system is essential. Hence, the impact interactions and pathways are to be understood and established first. Such an understanding will help in the assessment process to quantify the impact as accurately as possible. Complex interactions, particularly in case of certain indirect or cumulative impacts, may give rise to non-linear responses which are often difficult to understand and therefore might be difficult to assess their significance. It is hence understood that indirect or cumulative impacts are more complex than the direct impacts. Currently the impact assessments are limited to direct impacts. In case mitigation measures are delineated before determining significance of the effect, the significance represents the residual effects.

However, the ultimate objective of an EIA is to achieve sustainable development. The development process shall invariably cause some residual impacts even after implementing an EMP effectively. Environmentalists today are faced with a vital, not-easy-to-answer question—"What is the tolerable level of environmental impact within the sustainable development framework?" As such, it has been recognized that every ecosystem has a threshold for absorbing deterioration and a certain capacity for self-regeneration. These thresholds based on concept of carrying capacity are as follows:

- Waste emissions from a project should be within the assimilative capacity of the local environment to absorb without unacceptable degradation of its future waste absorptive capacity or other important services.
- Harvest rates of renewable resource inputs should be within the regenerative capacity of the natural system that generates them; depletion rates of non-renewable inputs should be equal to the rate at which renewable substitutes are developed by human invention and investment.

The aim of this model is to curb over-consumption and unacceptable environmental degradation. But because of limitation in available scientific basis, this definition provides only general guidelines for determining the sustainable use of inputs and outputs. For establishing the level of significance to each identified impact, a three-stage analysis may be referred:

- First, an impact is qualified as being either negative or positive.
- Second, the nature of impacts such as direct, indirect, or cumulative is determined using the impact network
- Third, a scale is used to determine the severity of the effect; for example, an impact is of low, medium, or high significance.

It is not sufficient to simply state the significance of the effect. This determination must be justified, coherent and documented, notably by a determination methodology, which must be described in the methodology section of the report. There are many recognized methodologies to determine the significance of effects.

2.9.1 Criteria/Methodology to Determine the Significance of the Identified Impacts

The criteria can be determined by answering some questions regarding the factors affecting the significance. This will help the EIA stakeholders, the practitioner in particular, to determine the significance of the identified impacts eventually. Typical

examples of such factors (one approach reported by Duval and Vonk 1994) include the following:

- Exceedance of a threshold: Significance may increase if the threshold is exceeded. For e.g., Emissions of SO_2 and/or PM10 exceed the permissible threshold.
- Effectiveness of mitigation: Significance may increase as the effectiveness of mitigation measures decreases. e.g., control technologies, which may not assure consistent compliance to the requirements.
- Size of study area: Significance may increase as the zone of effects increases. e.g., High temperature discharge from a cooling tower into the sea may impact the mangrove ecology at a distant location.
- Incremental contribution of effects from action under review: Significance may increase as the relative contribution of an action increases.
- Relative contribution of effects of other actions: Significance may decrease as the significance of nearby larger actions increase.
- Relative rarity of species: Significance may increase as a species becomes increasingly rare or threatened.
- Significance of local effects: Significance may increase as the significance of local effects is high.
- Magnitude of change relative to natural background variability: Significance may decrease if effects are within natural assimilative capacity or variability.
- Creation of induced actions: Significance may increase as the significance of the induced activities is also high.
- Degree of existing disturbance: Significance may increase if the surrounding environment is pristine.

For determining the significance of impacts, it is important to remember that secondary and higher order effects can also occur as a result of a primary interaction between the project activity and local environment. Where a primary effect is identified, the practitioner should always think if secondary or tertiary effects on other aspects of the environment could also arise.

The EIA should also consider the effects that could arise from the project due to induced developments, which take place as a consequence of the project. Ex., Population density and associated infrastructure and jobs for people attracted to the area by the project. It also requires consideration of cumulative effects that could arise from a combination of the effects due to other projects with those of other existing or planned developments in the surrounding area. So the necessity to formulate a qualitative checklist is suggested to test significance, in general.

3. ONSHORE AND OFFSHORE OIL & GAS EXPLORATION, DEVELOPMENT & PRODUCTION

3.1 Introduction

India has substantial quantity of oil reserves in its territory. So far 26 sedimentary basins of hydrocarbon potential have been identifies within the country. Bombay high, KG basin, Cambay, Cauvery, Assam, Andaman and Nicobar Islands, Rajasthan, *etc.*, are a few of the major sedimentary basins. The sedimentary basins of India, onshore and offshore up to the 200 meter (m) isobath, have an areal extent of about 1.79 million square kilometer (km^2). In the deep waters beyond the 200 m isobath, the sedimentary area has been estimated to be about 1.35 million km2. Thus the total sedimentary area basins including onshore and offshore areas within Indian territorial limits works out to be 3.14 million km2 of which about 15% of area is still unexplored. The sedimentary basin map of India is shown in Figure 3.1. The sedimentary basins are divided into four categories based on their degree of prospect as presently known. The details of categorization and sedimentary basinal areas are given in Figure 3-1 and Figure 3-2 respectively.

India largely depends on Gulf Countries for its oil and gas requirements. Currently 70% of the domestic hydrocarbon requirements are being imported and are rapidly rising due to the rapid development. The oil companies in the country produce about 34 million tones of oil per annum and 65 million standard cubic meters of gas per day. ONGC alone accounts for 77% of the oil and gas produced in India.

The national oil companies *i.e*. Oil & Natural Gas Corporation Limited (ONGC) and Oil India Ltd. (OIL) and private companies that work independently or as joint Venture (JV) with national oil companies are engaged in the Exploration and Production (E&P) of oil and natural gas in the country. The private companies include Reliance India Ltd (RIL), Cairn Energy, Essar, British Gas, Niko Resources, Hardly Oil, Gujarat State Petrochemicals Ltd. (GSPCL), Phoenix, Premier Oil, HOEC *etc.*

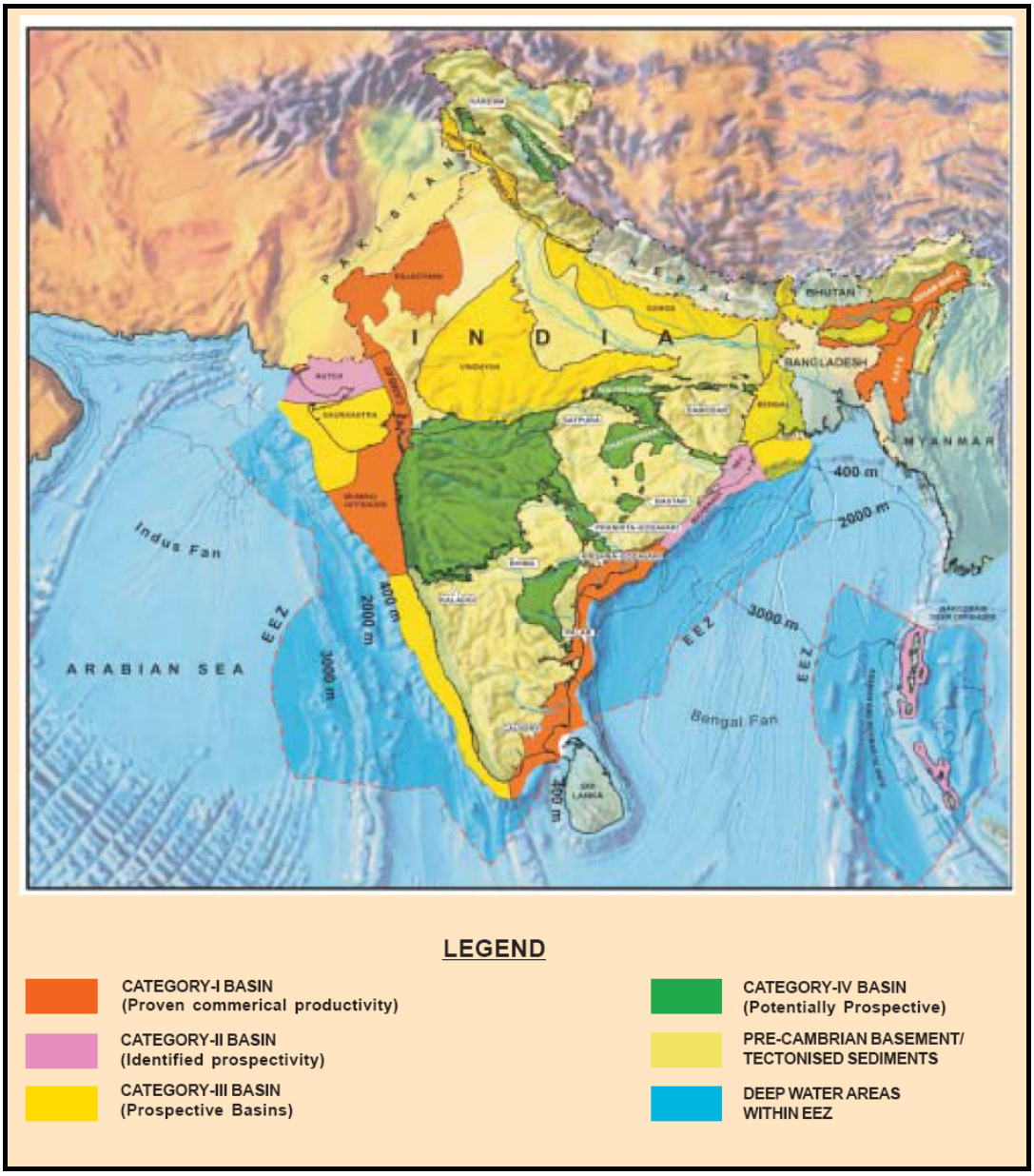


Figure 3-1: Sedimentary Basins of India

Category*	Basin	Basinal Area (Sq. Km.) Onland	Offshore	Total
UP TO 200M ISOBATH				
I	Cambay	51,000	2,500	53,500
	Assam Shelf	56,000	- - - -	56,000
	Mumbai offshore	- - - -	116,000	116,000
	Krishna Godavari	28,000	24,000	52,000
	Cauvery	25,000	30,000	55,000
	Assam-Arakan Fold Belt	60,000	- - - -	60,000
	Rajasthan	126,000	- - - -	126,000
	SUB. TOTAL	**346,000**	**172,500**	**518,500**
II	Kutch	35,000	13,000	48,000
	Mahanadi-NEC	55,000	14,000	69,000
	Andaman-Nicobar	6,000	41,000	47,000
	SUB. TOTAL	**96,000**	**68,000**	**164,000**
III	Himalayan Foreland	30,000	- - - -	30,000
	Ganga	186,000	- - - -	186,000
	Vindhyan	162,000	- - - -	162,000
	Saurashtra	52,000	28,000	80,000
	Kerala-Konkan-Lakshadweep	- - - -	94,000	94,000
	Bengal	57,000	32,000	89,000
	SUB. TOTAL	**487,000**	**154,000**	**641,000**
IV	Karewa	3,700	- - - -	3,700
	Spiti-Zanskar	22,000	- - - -	22,000
	Satpura-South Rewa-Damodar	46,000	- - - -	46,000
	Narmada	17,000	- - - -	17,000
	Deccan Syneclise	273,000	- - - -	273,000
	Bhima-Kaladgi	8,500	- - - -	8,500
	Cuddapah	39,000	- - - -	39,000
	Pranhita-Godavari	15,000	- - - -	15,000
	Bastar	5,000	- - - -	5,000
	Chhattisgarh	32,000	- - - -	32,000
	SUB. TOTAL	**461,200**	- - - -	**461,200**
	TOTAL	**1,390,200**	**394,500**	**1,784,700**
DEEP WATERS				
	Kori-Comorin 85^0 E Narcodam	- - - -	- - - -	1,350,000
GRAND TOTAL		- - - -	- - - -	**3,134,700**

* Categorization based on the prospectivity of the basin as presently known. The four recognized categories are basins which have :

I Established commercial production

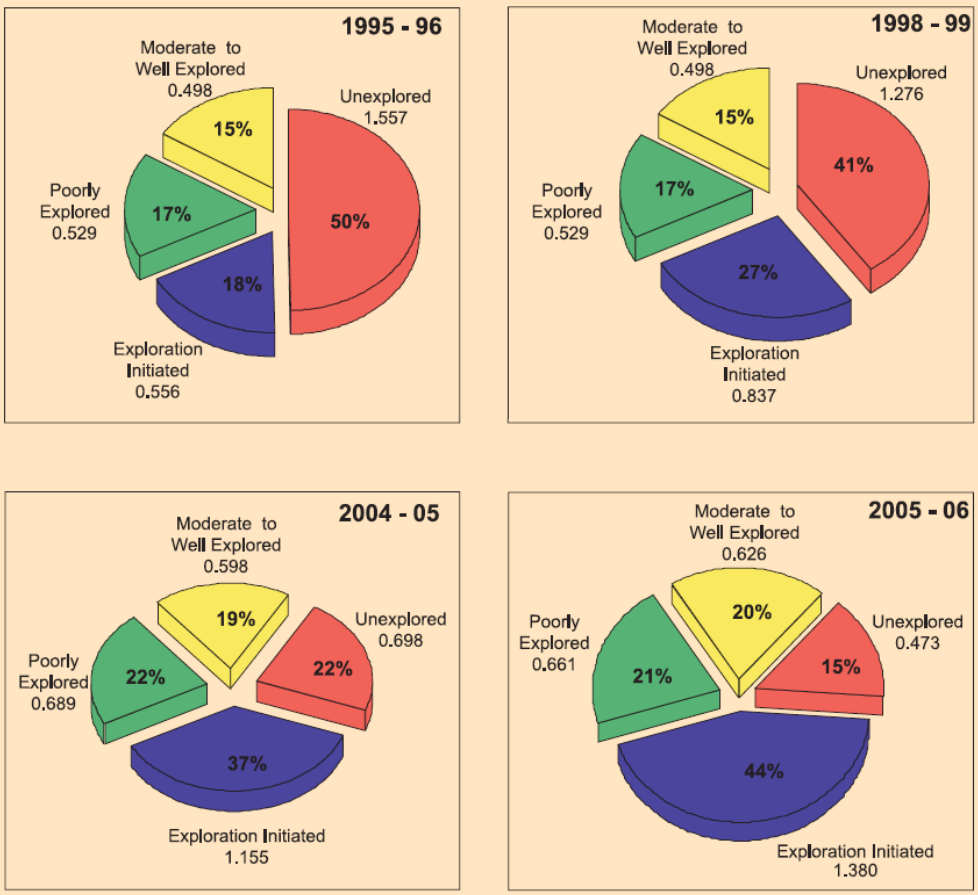
II Known accumulation of hydrocarbons but no commercial production as yet

III Indicated hydrocarbon shows that are considered geologically prospective

IV Uncertain potential which may be prospective by analogy with similar basins in the world.

This categorization will necessarily change with the results of further exploration.

Figure 3-2: Categorization of Sedimentary Basins



Total Sedimentary Area : 3.14 Million Sq. Km.

LEVEL OF EXPLORATION	AREA (Million Sq. Km.)			
	1995 - 96	1998 - 99	2004 - 05	2005 - 06
UNEXPLORED	1.557	1.276	0.698	0.473
EXPLORATION INITIATED	0.556	0.837	1.155	1.380
POORLY EXPLORED	0.529	0.529	0.689	0.661
MODERATE TO WELL EXPLORED	0.498	0.498	0.598	0.626

Figure 3-3: Sedimentary Basinal Areas

3.1.1 New significant discoveries

3.1.1.1 Discoveries by national oil companies (NOC) in nomination blocks

In the last six years (2000-06), the NOCs viz., ONGC and OIL made 38 significant hydrocarbon discoveries of which 13 are offshore and 25 on land. Out of 13 offshore discoveries, 8 were made in Kutch & Mumbai Basins, Western Offshore, and 5 in KG basin, Eastern Offshore. All these offshore discoveries were by ONGC. In 2005-06, discoveries made by ONGC are B-9-1(Gas) within Daman Fm. in Saurashtra-Dahanu and RV-1 (Gas) within Panna Fm. in Western Offshore and GS-15-E-1 (Gas) within Ravva Fm. in (KG) Eastern Offshore.

Out of the 25 Onland discoveries, 13 discoveries were made by OIL in Upper Assam Shelf and 12 discoveries were made by ONGC in Rajasthan, Cambay, Cauvery, K-G and in Assam Arakan Basins. In 2005-06, discoveries made by OIL were Moran-109 (Gas) in Oligocene Barail Sand, Bazaloni-1 (Oil & Gas) in Oligocene Barail Sand, Moran-107 (Oil & Gas) in Lakadong + Therria Sand of Eocene age, Baghjan-2 (Oil & Gas) and Barekuri-4 (Oil & Gas) in Langpar Sand of Late Cretaceous age. The discoveries made by ONGC were Turputallu (gas) in K-G and Mekeypore (Oil) in Upper Assam Shelf.

3.1.1.2 Discoveries by private / JV companies

In the last 6 years, under PSC regime Pvt/JV companies have made 59 significant hydrocarbon discoveries (as on September, 06), both in the NELP and Pre-NELP blocks. These discoveries were made in five major areas: Krishna-Godavari Offshore, Mahanadi-NEC Offshore, Gulf of Cambay, onland Rajasthan and Cambay Basins.

RIL made a series of oil & gas discoveries in their deep water block KG-DWN-98/3 through the drilling and testing of Dhirubhai wells 18, 19, 22, 23 and 26. In the block KG-OSN-2001/2 Reliance has discovered oil & gas in Dhirubhai-24 and 25. Recently in the block KG-OSN-2001/1 RIL has discovered oil & gas reserves in Dhirubhai #28.

Recent gas discoveries namely Dhirubhai – 20, 21 in Upper Miocene Pay Sand made by RIL in shallow offshore block NEC-OSN-97/2 located in Mahanadi-NEC basin have upgraded the category of the basin from Cat.-III to Cat.-II. When these discoveries are put on production along with earlier discoveries, the category of the basin will be further upgraded to Cat.-I and will become the 8th basin with established commercial production.

In deepwater block KG-DWN-98/2, M/s. ONGC made three important discoveries: DWN-A-1 (Gas), U-1 (Gas) & W-1 (Gas).

Recently in block CB-ONN-2000/1, GSPC has discovered oil & gas in Sanand East(1) in Olpad. It also discovered oil in Kalol in well Tarapur-1 in CB-ON/2 block. In offshore block KG-OSN- 2001/3, M/s. GSPC has discovered gas in KG-8 well in Lower Cretaceous Sand and oil & gas in KG-17 well in Upper Cretaceous Sand. In CB-ON/3 block, M/s. Essar Oil has discovered oil in ESU-1 well and its commerciality was approved in August, 2006. In Panna-Mukta field BGEPIL discovered oil and gas in SW Panna (SWP-1) in Bassein Limestone of Eocene-Oligocene age.

In the Rajasthan onland block RJ-ON-90/1 in Barmer-Sanchor sub-basin, Cairn Energy has made a string of oil & gas discoveries viz., NI-2, NC-west-1 & GS-V-1 in Fathegarh

Fm. These discoveries along with previous discoveries have put Rajasthan firmly on the oil map of India. In RJ-ON/6 block FOCUS Energy has discovered gas in SGL-1 well.

Source: Directorate General of Hydrocarbons (DGH)

3.1.2 Exploration & production (E&P) data statistics

3.1.2.1 Resources and reserves

The hydrocarbon resources, inclusive of deep waters, are estimated at around 28 billion tones oil and oil-equivalent of gas (O+OEG). As on 01.04.2006, initial in place oil of 8.46 billion tonnes and ultimate reserves of 3.25 billion tonnes have been established. The resources estimated by DGH for its 'internal use', for the country, are 32 billion tonnes (O+OEG).

3.1.2.2 Seismic surveys

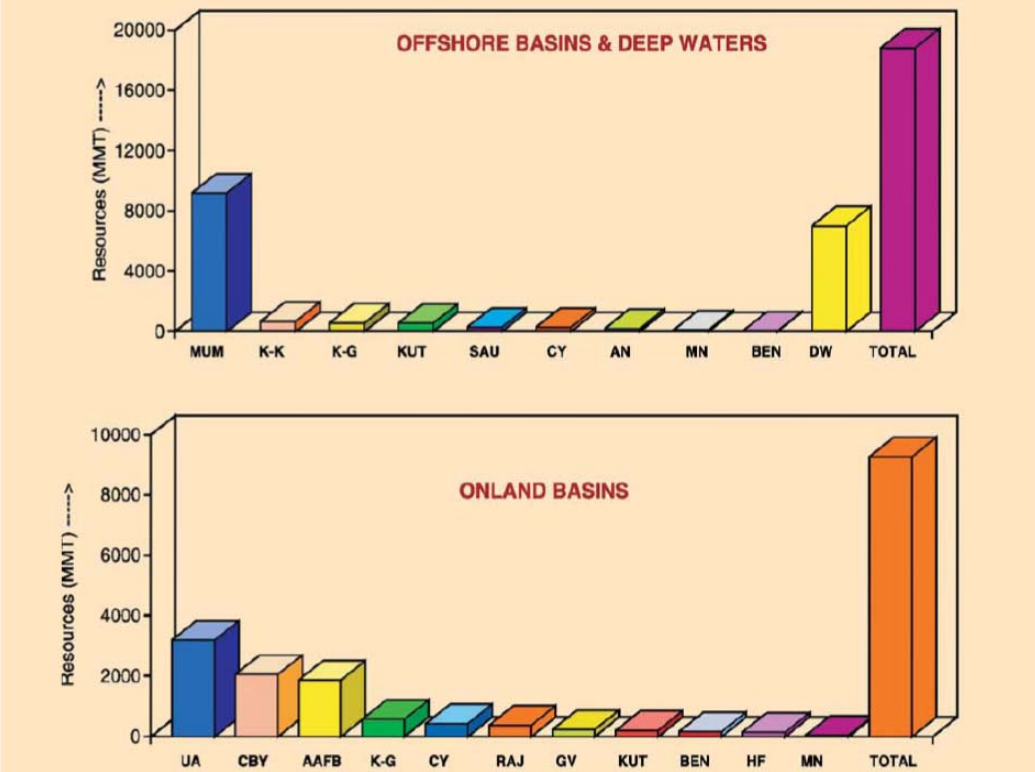
- During the year 2005-06, 2-D seismic data acquisition comprised 7,265.17 LKM onland and 12,780.48 LKM offshore data.
- In respect of 3-D seismic data, 4,415.64 km^2 onland and 39,344.10 km^2 offshore data were acquired.
- A total of 16 2D seismic parties and 27 3D seismic parties were deployed in onland areas. 8 seismic vessels were engaged to carryout 2D and 3D seismic surveys in offshore areas.

3.1.2.3 Drilling

During 2003-04, a total of 418 hydrocarbon wells were drilled where 198 were exploratory and 220 development wells. The NOCs contributed to the bulk of the drilling. A total of 11,09,480 m were drilled, including 561,620 m of exploratory and 547,860 m of development drilling

3.1.2.4 Production

Total oil production during the year was over 32.189 million metric tonne (MMT) and that of gas 32.200 billion cubic metre (BCM). The contribution of Private/ Joint Venture companies was about 18% of the total Oil & OEG production. Relevant details are given below in Figures 3.4 -3.10.

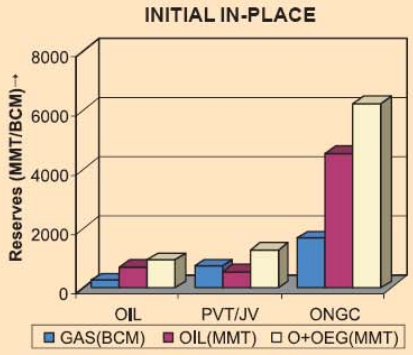


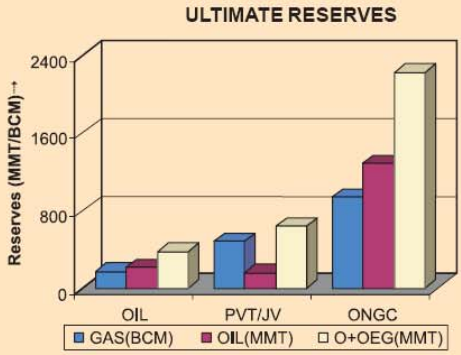
BASIN-WISE HYDROCARBON RESOURCES (MMT)

BASIN	OFFSHORE	ONLAND	TOTAL
MUMBAI (MUM)	9,190	---	9,190
ASSAM-ARAKAN FOLD BELT (AAFB)	---	1,860	1,860
CAMBAY (CBY)	---	2,050	2,050
UPPER ASSAM (UA)	---	3,180	3,180
KRISHNA-GODAVARI (K-G)	555	575	1,130
CAUVERY (CY)	270	430	700
RAJASTHAN (RAJ)	---	380	380
KUTCH (KUT)	550	210	760
ANDAMAN-NICOBAR (AN)	180	---	180
KERALA-KONKAN (K-K)	660	---	660
SAURASHTRA OFFSHORE (SAU)	280	---	280
GANGA VALLEY (GV)	---	230	230
BENGAL (BEN)	30	160	190
HIMALAYAN FORELAND (HF)	---	150	150
MAHANADI (MN)	100	45	145
DEEP WATER (DW)	7,000	---	7,000
GRAND TOTAL	18,815	9,270	28,085

Figure 3-4: Total Hydrocarbon Resources (as on 01-04-2006)

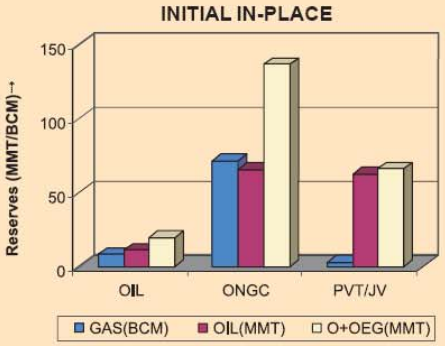
INITIAL IN-PLACE AND ULTIMATE RESERVES OF HYDROCARBONS
(AS ON 01-04-2006)

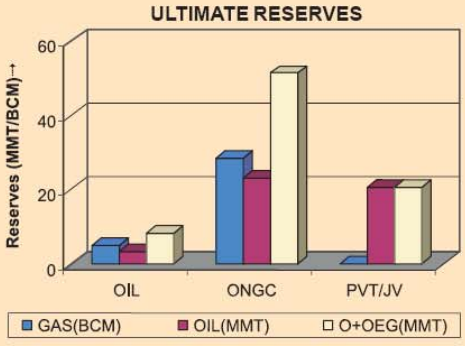




COMPANY	INITIAL IN-PLACE			ULTIMATE RESERVES		
	GAS(BCM)	OIL(MMT)	O+OEG(MMT)	GAS(BCM)	OIL(MMT)	O+OEG(MMT)
OIL	251.09	687.56	938.65	170.00	209.07	379.07
PVT/JV	724.95	548.77	1273.72	483.41	155.86	639.27
ONGC	1688.31	4563.84	6252.15	942.27	1287.84	2230.11
GRAND TOTAL	**2664.35**	**5800.17**	**8464.52**	**1595.68**	**1652.77**	**3248.45**

ACCRETION OF IN-PLACE AND ULTIMATE RESERVES ACHIEVED
DURING 2005-2006

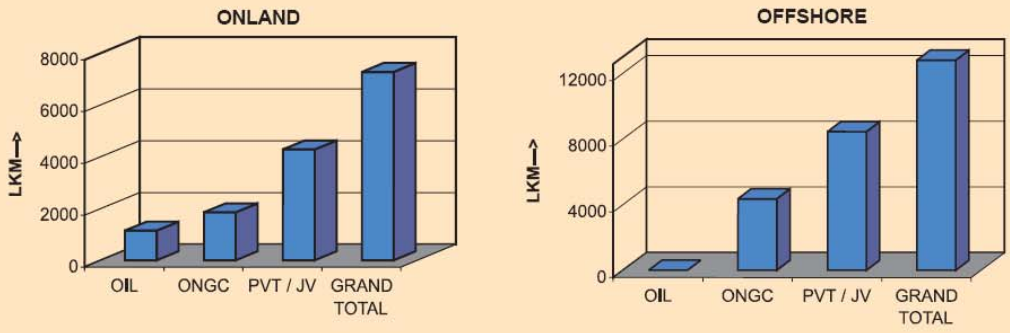




COMPANY	INITIAL IN-PLACE			ULTIMATE RESERVES		
	GAS(BCM)	OIL(MMT)	O+OEG(MMT)	GAS(BCM)	OIL(MMT)	O+OEG(MMT)
OIL	8.35	11.38	19.73	5.03	3.36	8.39
ONGC	71.58	65.44	137.02	28.44	23.09	51.53
PVT/JV	3.14	62.90	66.04	0.09	20.67	20.76
GRAND TOTAL	83.07	139.72	222.79	33.56	47.12	80.68

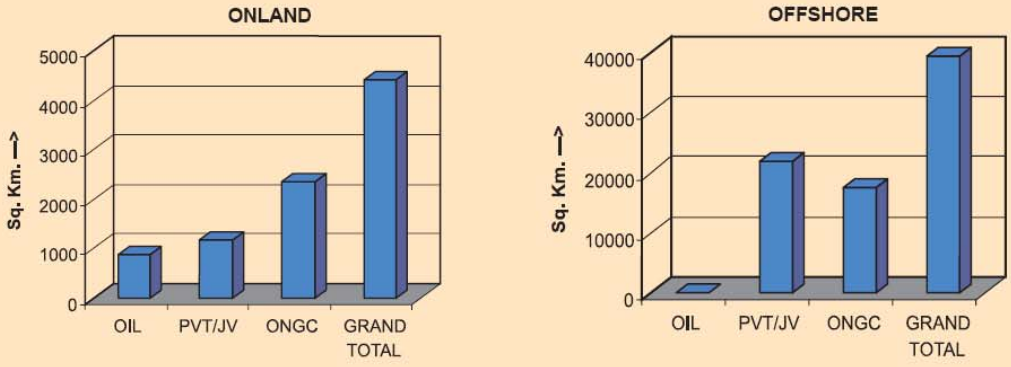
Figure 3-5: Reserves and Accretion of Hydrocarbons

2D - SEISMIC DATA ACQUIRED(2005-06)



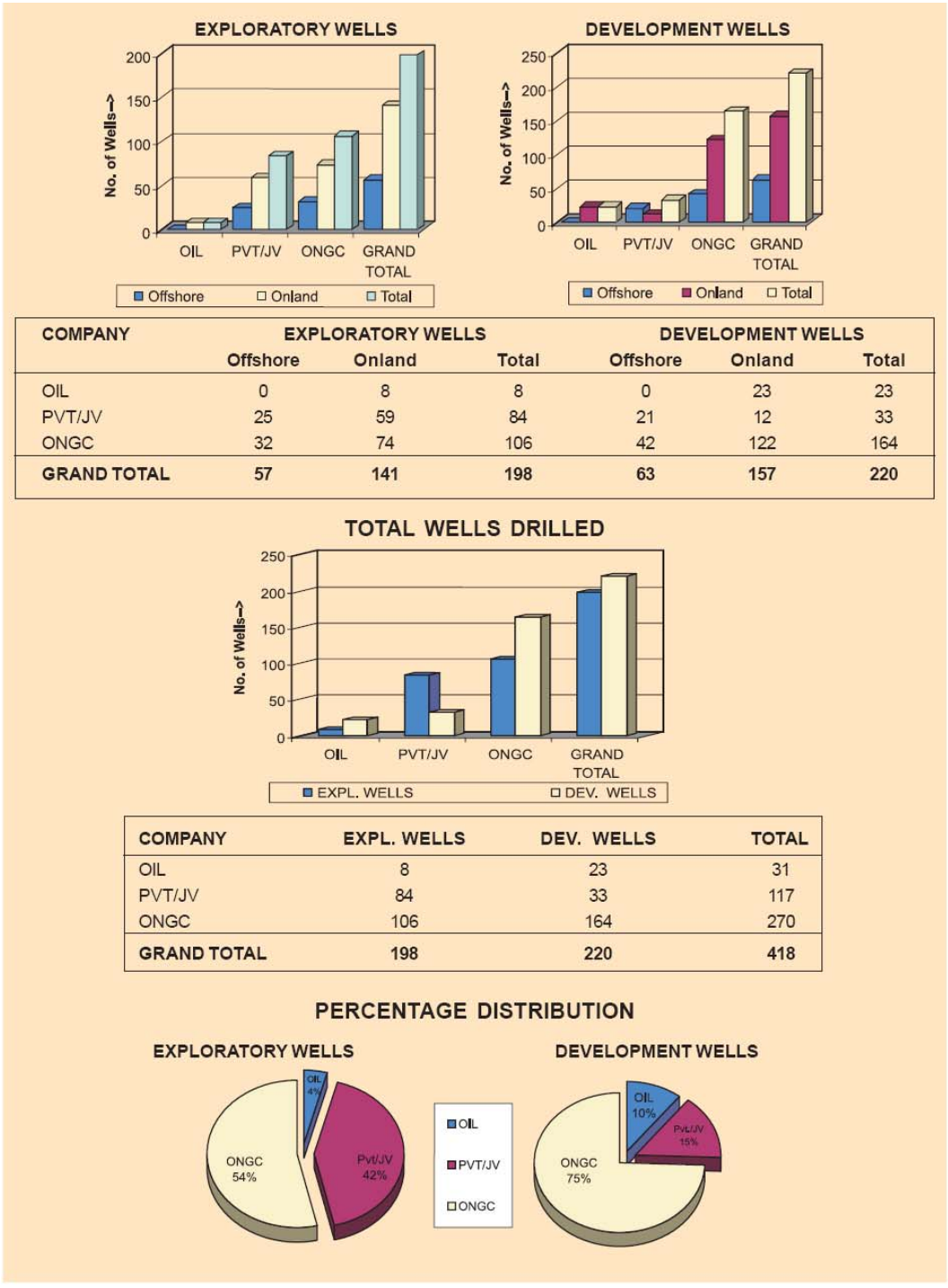
COMPANY	ONLAND LKM	OFFSHORE LKM
OIL	1143.75	0.00
ONGC	1847.42	4349.48
PVT / JV	4274.00	8431.00
GRAND TOTAL	**7265.17**	**12780.48**

3D - SEISMIC DATA ACQUIRED(2005-06)



COMPANY	ONLAND Sq. Km.	OFFSHORE Sq. Km.
OIL	889.90	0.00
PVT / JV	1167.00	21838.00
ONGC	2358.74	17506.10
GRAND TOTAL	**4415.64**	**39344.10**

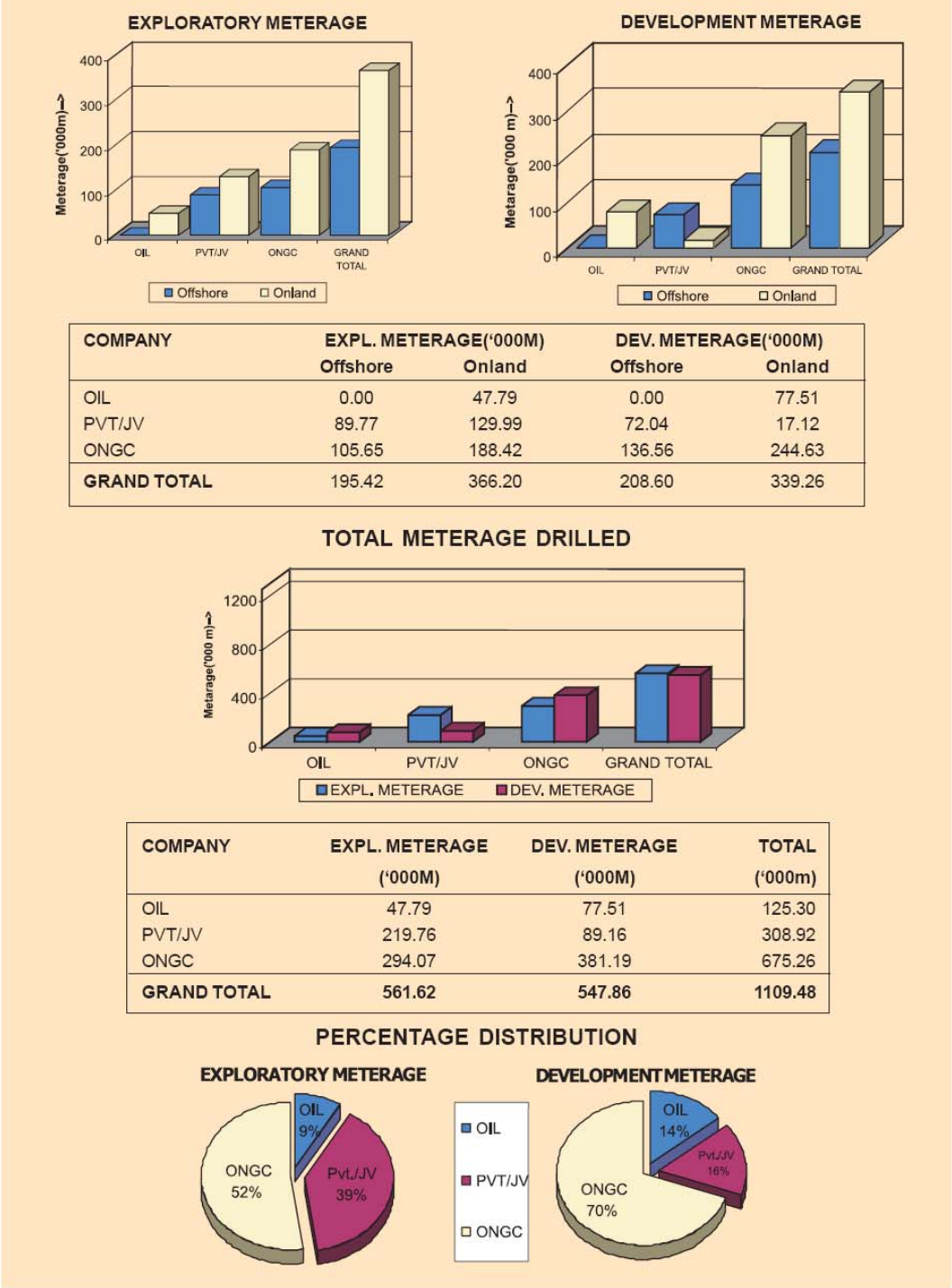
Figure 3-6: Seismic Data



COMPANY	EXPLORATORY WELLS			DEVELOPMENT WELLS		
	Offshore	Onland	Total	Offshore	Onland	Total
OIL	0	8	8	0	23	23
PVT/JV	25	59	84	21	12	33
ONGC	32	74	106	42	122	164
GRAND TOTAL	**57**	**141**	**198**	**63**	**157**	**220**

COMPANY	EXPL. WELLS	DEV. WELLS	TOTAL
OIL	8	23	31
PVT/JV	84	33	117
ONGC	106	164	270
GRAND TOTAL	**198**	**220**	**418**

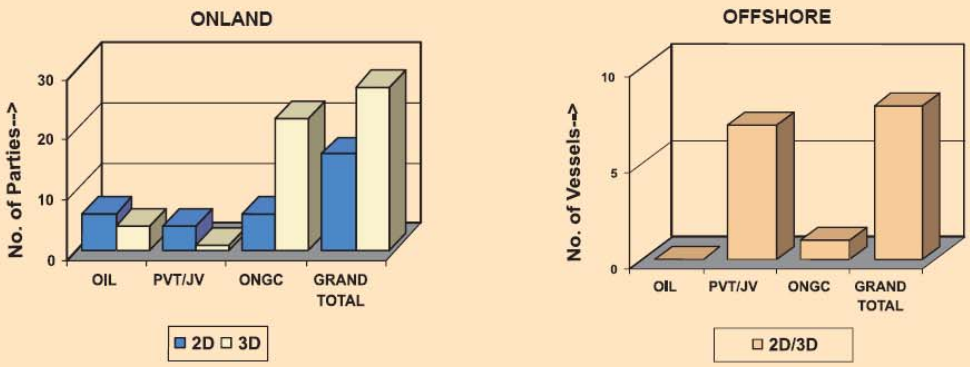
Figure 3-7: Exploratory and Development Wells Drilled (2005-06)



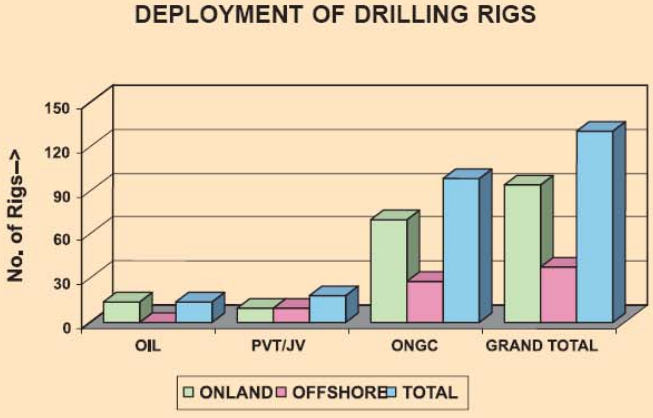
COMPANY	EXPL. METERAGE('000M)		DEV. METERAGE('000M)	
	Offshore	Onland	Offshore	Onland
OIL	0.00	47.79	0.00	77.51
PVT/JV	89.77	129.99	72.04	17.12
ONGC	105.65	188.42	136.56	244.63
GRAND TOTAL	195.42	366.20	208.60	339.26

COMPANY	EXPL. METERAGE ('000M)	DEV. METERAGE ('000M)	TOTAL ('000m)
OIL	47.79	77.51	125.30
PVT/JV	219.76	89.16	308.92
ONGC	294.07	381.19	675.26
GRAND TOTAL	**561.62**	**547.86**	**1109.48**

Figure 3-8: Exploratory and Development Meterage Drilled (2005-06)

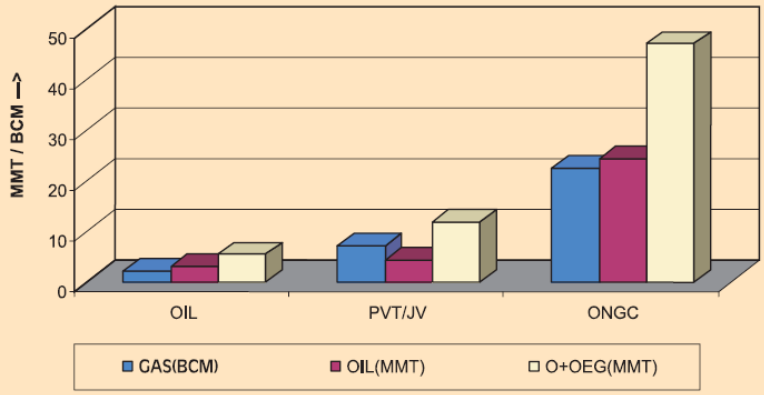


COMPANY	ONLAND (Parties)		OFFSHORE (Vessels)	TOTAL
	2D	3D	2D/3D	
OIL	6	4	0	10
PVT/JV	4	1	7	12
ONGC	6	22	1	29
GRAND TOTAL	**16**	**27**	**8**	**51**

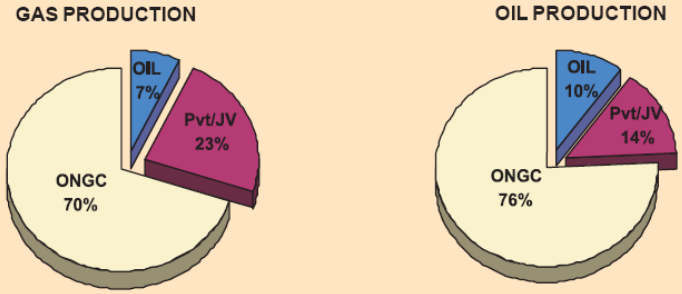


COMPANY	ONLAND	OFFSHORE	TOTAL
OIL	14	0	14
PVT/JV	9	9	18
ONGC	70	28	98
GRAND TOTAL	**93**	**37**	**130**

Figure 3-9: Seismic Parties/ Vessels Deployed (2005-2006)



PERCENTAGE DISTRIBUTION



COMPANY	GAS(BCM)	OIL(MMT)	O+OEG(MMT)
OIL	2.269	3.233	5.502
PVT/JV	7.357	4.552	11.909
ONGC	22.574	24.404	46.978
GRAND TOTAL	**32.200**	**32.189**	**64.389**

Figure 3-10: Oil and Gas Production (2005-06)

3.2 Scientific Aspects

3.2.1 Industrial process

The oil & gas industry comprises of three segments, Upstream, Midstream & Downstream.

- Upstream segment deals with oil & gas exploration and production
- Midstream deals with the transportation of crude oil petroleum products, transportation of natural gas and LNG receiving terminals
- Downstream segment deals with refining, gas processing and marketing of oil & gas to the ultimate consumers

In the Indian context initially companies were set up for a specific purpose but after liberalization almost all the companies are now getting to be fully integrated (involving in the above mentioned streams).

The primary products of the oil and gas industry are crude oil, natural gas liquids, and natural gas. Crude oil consists of a mixture of hydrocarbons having varying molecular weights and properties.

Natural gas can be produced from oil wells, or wells can be drilled with natural gas as the primary product. Methane is the predominant component of natural gas, but ethane, propane, and butane could also be the significant components. The heavier components, including propane and butane, exist as liquids when cooled and compressed and these are often separated and processed as LPG.

The oil and gas extraction industry can be classified into four major processes:

- exploration
- appraisal
- development and production, and
- decommissioning and abandonment.

3.2.1.1 Exploration activities

A. Exploration surveying

In the first stage of the search for hydrocarbon-bearing rock formations, geological maps are reviewed in desk studies to identify major sedimentary basins. Aerial photography can be used to identify promising landscape formations such as faults or anticlines. More detailed information is assembled using a field geological assessment, followed by one of three main survey methods: magnetic, gravimetric and seismic.

The magnetic method depends on measuring the variations in intensity of the magnetic field which reflects the magnetic character of the various rocks present, while the gravimetric method involves the measurement of small variations in the gravitational field at the surface of the earth. Measurements are made, on land and at sea, using an aircraft or a survey ship respectively.

Seismic surveys are the most common assessment methods used to pinpoint potential hydrocarbon reserves in geological formations. Seismic technology uses the reflection of sound waves to identify subsurface geological structures. The surveys are conducted through the generation of seismic waves by a variety of sources ranging from explosives that are detonated in shot-holes drilled below the surface, to vibroseis machinery (a vibrating pad lowered to the ground from a vibroseis truck). Reflected seismic waves are measured with a series of sensors known as geophones laid out in series on the surface. A typical seismic survey is illustrated in Figure 3-11.

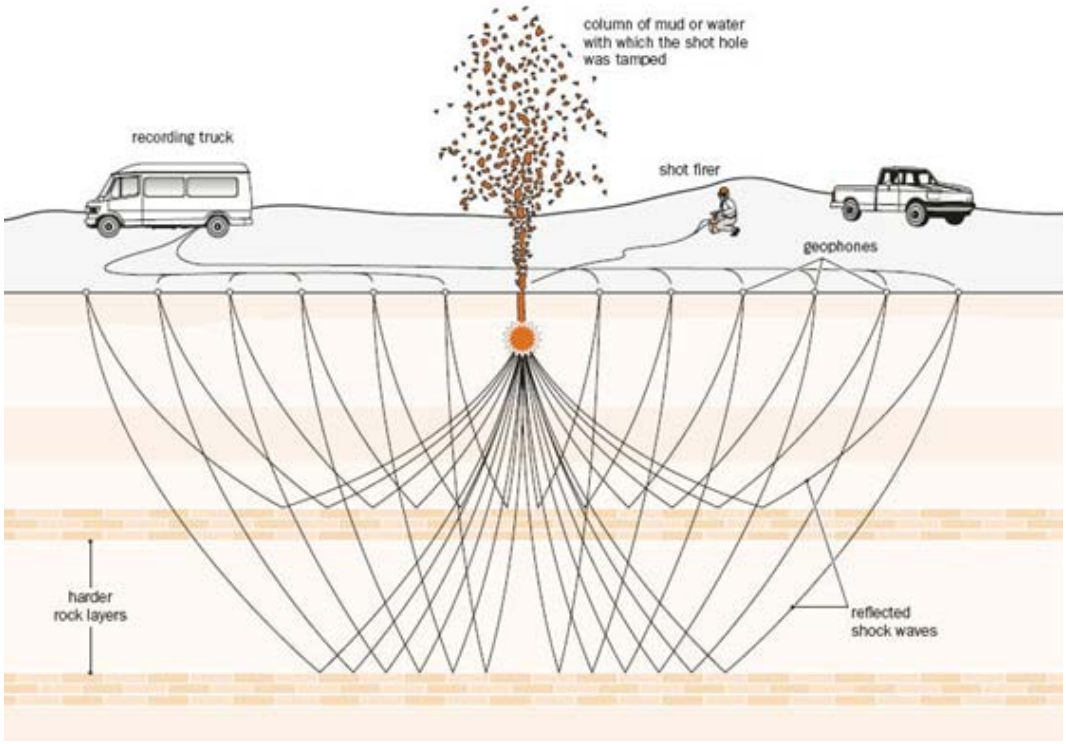


Figure 3-11: Seismic Surveys

Source: Joint E&P Forum/ UNEP Technical Publication

In modern marine seismic surveys, as many as 16 "streamers" (cables containing the hydrophones used to detect the sound reflected from the subsurface) are towed behind the seismic vessel, at a depth of 5 to 10 m. Each cable can be as long as 8 to 10 km. In addition to the hydrophone array, the vessel tows seismic source arrays comprising a number of air guns which discharge sound bursts of between 200–250 decibels (dB) downward. The sound bursts, repeated on average every 6 to 10 seconds, are reflected off deep geological formations and recorded by the hydrophone array.

B. Exploration drilling

Exploratory drilling activities onshore/ offshore follow the analysis of seismic data to verify and quantify the amount and extent of oil and gas resources from potentially productive geological formations. Most of the exploratory boreholes are drilled to confirm the presence of hydrocarbons and the thickness and internal pressure of a reservoir. However, some are also drilled to gain knowledge of the geological formation. All wells that are drilled to discover hydrocarbons are called 'exploration' wells,

commonly known by drillers as 'wildcats'. The location of a drill site depends on the characteristics of the underlying geological formation.

For onshore operations, a well pad is constructed at the chosen location to accommodate a drilling rig, associated equipment and support services. A pad for a single exploration well occupies between 4000–15000 square meter (m^2). The type of pad construction depends on terrain, soil conditions and seasonal constraints. The drilling rig and support services are transported to site, typically in modules and assembled. Typical drilling rig modules, as shown in figure 3-12, include a derrick, drilling mud handling equipment, power generators, cementing equipment and tanks for fuel and water.

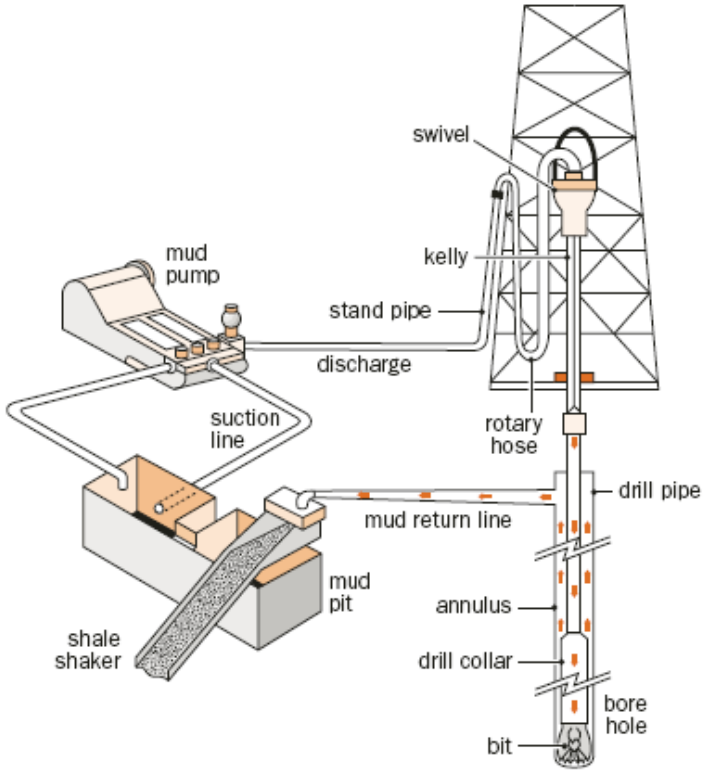


Figure 3-12: Drilling

Source: Joint E&P Forum/ UNEP Technical Publication

Operations over water can be conducted using a variety of self-contained mobile offshore drilling units (MODUs), the choice of which depends on the depth of water, seabed conditions and prevailing meteorological conditions, - particularly wind speed, wave height and current speed.

The following are the various types of mobile offshore drilling rigs:

- Jack-up rigs: Suitable for shallow water up to 100 m deep and transported to location either under their own propulsion, or towed by tugs. Once there, electric or hydraulic jacks lower three or four legs to the seafloor to support the drilling platform above water.

- Semi-submersible rigs: Suitable for deep waters and transported to location either under their own propulsion, or towed by tugs. The hull is partially submerged and the rig held in place by a series of anchors.
- Submersible rigs: Limited to shallow waters and towed onto location. Consisting of two hulls: an upper hull, or platform, and lower hull that is filled with water and submerged to the seafloor.
- Drilling barges as floating platform: Suitable for shallow waters, estuarine areas, lakes, marshes, swamps and rivers. Not suitable for open or deep water. Towed onto location.
- Drillships: Designed for drilling in deep water locations. Drilling takes place from a drilling platform and derrick positioned in the middle of the deck, from which drill stems are lowered through a hole in the hull (moonhole).

Once on location, a series of well sections of decreasing diameter are drilled from the rig. A drill bit, attached to the drill string suspended from the rig's derrick, is rotated in the well. Drill collars are attached to add weight and drilling fluids are circulated through the drill string and pumped through the drill bit. Drilling operations are generally conducted round-the-clock. The time taken to drill a bore hole depends on the depth of the hydrocarbon bearing formation and the geological conditions, but it is commonly of the order of one or two months. Where a hydrocarbon formation is found, initial well tests – possibly lasting another month – are conducted to establish flow rates and formation pressure. These tests may generate oil, gas and formation water – each of which needs to be disposed off.

After drilling and initial testing, the rig is usually dismantled and moved to the next site. If the exploratory drilling has discovered commercial quantities of hydrocarbons, a wellhead valve assembly may be installed. If the well does not contain commercial quantities of hydrocarbon, the site is decommissioned to a safe and stable condition and restored to its original state or an agreed after use. Open rock formations are sealed with cement plugs to prevent upward migration of wellbore fluids. The casing of the wellhead and the top joint of the casings are cut below the ground level and capped with a cement plug.

Drilling fluids

The fluid has a number of functions. It imparts hydraulic force that assists the drill bit cutting action, and it cools the bit, removes cuttings rock from the wellbore and protects the well against formation pressures. When each well section has been drilled, steel casing is run into the hole and cemented into place to prevent well collapse. When the reservoir is reached the well may be completed and tested by running a production liner and equipment to flow the hydrocarbons to the surface to establish reservoir properties in a test separator. Various drilling fluids are available, but they can generally be categorized into one of two fluid systems:

- Water-Based Drilling Fluids (WBDF): Fluids where the continuous phase and suspending medium for solids is seawater or a water miscible fluid. There are many WBDF variations, including gel, salt-polymer , salt-glycol and salt-silicate fluids;
- Non-Aqueous Drilling Fluids (NADF): The continuous phase and suspending medium for solids is a water immiscible fluid that is oil-based, enhanced mineral oil-based, or synthetic-based.

- Diesel-based fluids are also available, but the use of systems that contain diesel as the principal component of the liquid phase is not considered current good practice for offshore drilling programs and should be avoided.

Typically, the solid medium used in most drilling fluids is barite (barium sulfate) for weight, with bentonite clays as a thickener. Drilling fluids also contain a number of chemicals that are added depending on the downhole formation conditions.

Drilling fluids are either circulated downhole with direct loss to the seabed along with displaced cuttings, particularly while drilling well sections nearest to the surface of the seabed, or are recirculated to the offshore facility where they are routed to a control system that filters solids. In this control system, the drilling fluids are separated from the cuttings so that they may be recirculated downhole leaving the cuttings behind for disposal. These cuttings contain a proportion of residual drilling fluid. The volume of cuttings produced will depend on the depth of the well and the diameter of the hole drilled.

The drilling fluid is replaced when its rheological properties or density of the fluid can no longer be maintained or at the end of the drilling program. These spent fluids are then contained for reuse or disposal.

Casing

As the hole is drilled, casing is placed in the well to stabilize the hole and prevent caving. The casing also isolates water-bearing and hydrocarbon-bearing zones. As shown in Figure 3-13 three or four separate casing "strings" (lengths of tubing of a given diameter) may be used in intermediate-depth wells. In locations where surface soils may cave in during drilling, a "conductor" casing may be placed at the surface, extending only twenty to one hundred feet from the surface. This string is often placed before the drilling starts. with a pile driver (Berger and Anderson, 1992). The next string, or "surface" casing, begins at the surface and may penetrate two thousand to three thousand feet deep. Its primary purpose is to protect the surrounding freshwater aquifer(s) from the incursion of oil or brine from greater depths. The "intermediate" string begins at the surface and ends within a couple thousand feet of the bottom of the wellbore. This section prevents the hole from caving in and facilitates the movement of equipment used in the hole, e.g., drill strings and logging tools. The final "production" string extends the full length of the wellbore and encases the downhole production equipment. Shallow wells may have only two casing strings, and deeper wells may have multiple intermediate casings. After each casing string has been installed, cement is forced out through the bottom of the casing up the annulus to hold it in place and surface casing is cemented to the surface. Casing is cemented to prevent migration of fluids behind the casing and to prevent communication of higher pressure productive formations with lower pressure non-productive formations. Additional features and equipment will be installed during the completion process for production. Perforations will allow reservoir fluid to enter the wellbore; tubing strings will carry the fluid to the surface; and packers (removable plugs) may be installed to isolate producing zones.

Casing is important for both drilling and production phases of operation, and must therefore be designed properly. It prevents natural gas, oil, and associated brine from leaking out into the surrounding freshwater aquifer(s), limits sediment from entering the wellbore, and facilitates the movement of equipment up and down the hole. Several considerations are involved in planning the casing. First, the bottom of the wellbore must be large enough to accommodate any pumping equipment that will be needed either upon commencement of pumping, or in the later years of production. Also, unusually

pressurized zones will require thicker casing in that immediate area. Any casing strings that must fit within this string must then be smaller, but must still accommodate the downhole equipment. Finally, the driller is encouraged to keep the size of the hole to a minimum; as size increases, so does cost and waste.

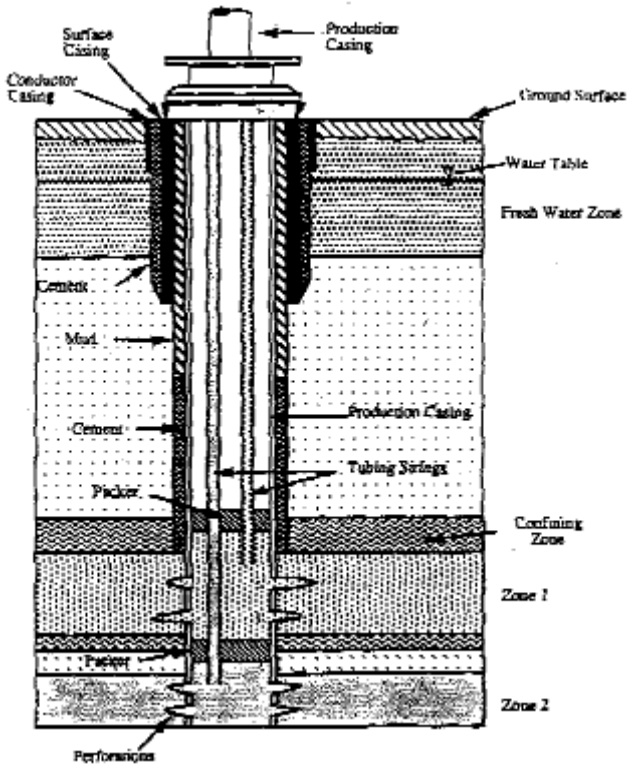


Figure 3-13: Cross-section of a Cased Well

Source: EPA

3.2.1.2 Appraisal

When exploratory drilling is successful, more wells are drilled to determine the size and the extent of the field. Wells drilled to quantify the hydrocarbon reserves found are called 'outstep' or 'appraisal' wells. The appraisal stage aims to evaluate the size and nature of the reservoir, to determine the number of confirming or appraisal wells required, and whether any further seismic work is necessary. The technical procedures in appraisal drilling are same as those employed for exploration wells, and the description provided above applies equally to appraisal operations. A number of wells may be drilled from a single site, which increases the time during which the site is occupied. Deviated or directional drilling at an angle from a site adjacent to the original discovery bore-hole may be used to appraise other parts of the reservoir, in order to reduce the land used or 'footprint'.

3.2.1.3 Field development and production

Development and production is the phase during which the infrastructure is installed to extract the hydrocarbon resource over the life of the estimated reserve. It may involve the

drilling of additional wells called development or production wells, the operation of central production facilities to treat the produced hydrocarbons, the installation of flow lines, and the installation of pipelines to transport hydrocarbons to export facilities.

A small reservoir may be developed using one or more of the appraisal wells. A larger reservoir will require the drilling of additional production wells. Multiple production wells are often drilled from one pad to reduce land requirements and the overall infrastructure cost. The number of wells required to exploit the hydrocarbon reservoir varies with the size of the reservoir and its geology. Large oilfields can require a hundred or more wells to be drilled, whereas smaller fields may only require ten or so. The drilling procedure involves similar techniques to those described for exploration; however, with a larger number of wells being drilled, the level of activity obviously increases in proportion. The well sites will be occupied for long and support services – workforce accommodation, water supply, waste management, and other services – will correspondingly increase. As each well is drilled it has to be prepared for production before the drilling rig departs. The heavy drill pipe is replaced by lighter weight tubing in the well and occasionally one well may carry two or three strings of tubing, each one producing from different layers of reservoir rock.

Following development drilling and well completion, a "Christmas tree" is placed on each wellhead to control flow of the formation fluids to the surface. Hydrocarbons may flow freely from the wells if the underground formation pressures are adequate, but additional pressure may be required such as a sub-surface pump or the injection of gas or water through dedicated injection wells to maintain reservoir pressure. Depending on reservoir conditions, various substances (steam, nitrogen, carbon dioxide, and surfactants) may be injected into the reservoir to remove more oil from the pore spaces, increase production, and extend well life.

Production from most wells follows a predictable pattern called a decline curve where production increases relatively rapidly to a peak, and then follows a long, slow decline. Operators may periodically perform well workovers to clean out the wellbore, allowing oil or gas to move more easily to the surface. Other measures to increase production include fracturing and treating the bottom of the wellbore with acid to create better pathways for the oil and gas to move to the surface. Formation fluids are then separated into oil, gas and water at a central production facility, designed and constructed depending on the reservoir size and location.

The production facility processes the hydrocarbon fluids. Crude oil processing essentially involves the removal of gas and water before export. Gas processing involves the removal of liquids and other impurities such as carbon dioxide, nitrogen and hydrogen sulfide. Oil and gas terminal facilities receive hydrocarbons from outside locations sometimes offshore and process and store the hydrocarbons before they are exported. There are several types of hydrocarbon terminals, including inland pipeline terminals, onshore / coastal marine receiving terminals (from offshore production), barge shipping, or receiving terminals. A schematic representation of a typical crude oil processing facility is shown in figure 3.14.

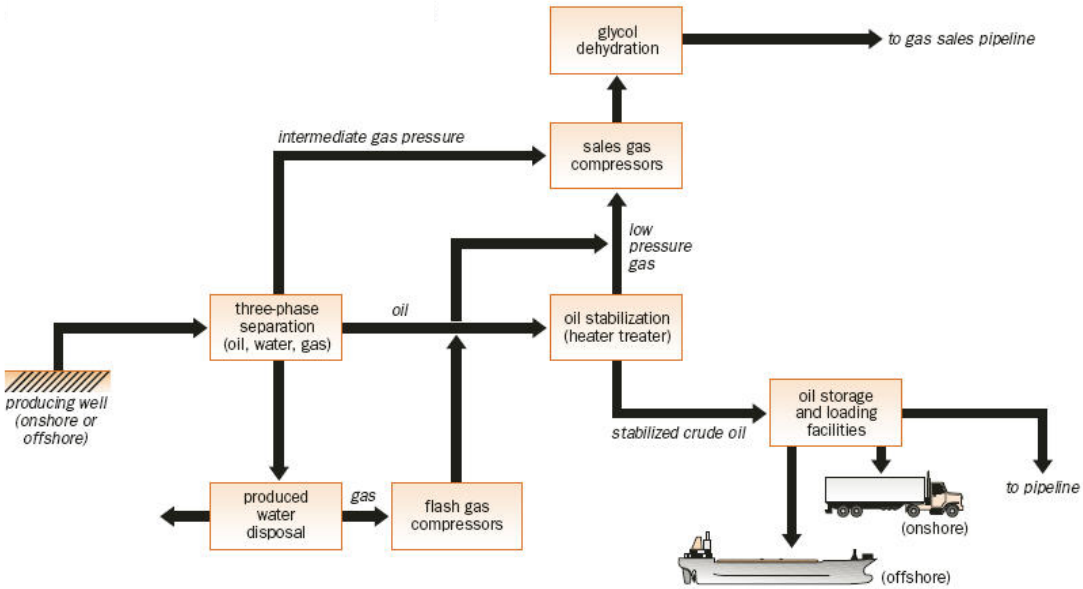


Figure 3-14: Typical Crude Oil/Gas Processing

Source: Joint E&P Forum/ UNEP Technical Publication

The infrastructure required for development drilling in onshore operations is similar to the one described above for exploration. However, once drilling is completed, the individual wellhead assemblies and well sites occupy considerably lesser space than when the drill rig was on site. Typically, each well requires an area of some 10 square meter (m^2) surrounded by a security fence. Often the well sites are concentrated within a central area, which includes processing facilities, offices and workshops, and this would typically occupy an area of several hectares, depending upon the capacity of the field. Since the production operation is a long-term development, the temporary facilities used in exploration are replaced by permanent facilities and are subject to detailed planning, design, engineering and construction. The temporary workforce associated with exploration activity is replaced by a permanent workforce, usually accommodated in the local area and, where desirable, fully integrated with the local community: indeed a large proportion of the workforce may be recruited locally and receive specialized training. Similarly, the local infrastructure provides a variety of requirements in addition to labour, such as material supplies, education, medical, *etc*.

In offshore production developments, permanent structures are necessary to support the required facilities, since typical exploration units are not designed for full scale production operations. This will involve the installation of an offshore drilling and production platform that is self sufficient in terms of energy and water needs for the workforce and for drilling wells and processing hydrocarbons ready for export.

There are many types of offshore platforms, including:

- Fixed platforms: Used in water depths up to 500 m. Consists of steel or concrete legs (jacket) secured directly to the seabed by steel piles that support a steel deck. Drilling equipment, production facilities and accommodation are typically housed on the deck.
- Compliant towers: Used in water depths ranging from 500 m to 1,000 m. These towers consist of a narrow, flexible tower on a piled foundation supporting a conventional deck.

- Tension leg platforms: Used in water depths of up to 2,000 m and consists of a floating facility moored to the seabed and fixed in place by anchors. Mini tension leg platforms (Seastars) exist that are used in water depths between 200 m and 1,000 m.
- Jack-up platforms: Used in shallower water up to 100m and transported to location where the legs are lowered by hydraulic jacks into position to support the deck.

Normally, a steel platform is installed to serve as the gathering and processing centre and more than 40 wells may be drilled directionally from this platform. Concrete platforms are sometimes used (see Figure 3-15). If the field is large enough, additional 'satellite' platforms may be needed, linked by subsea flow lines to the central facility. In shallow waters, typically a central processing facility is supported by a number of smaller wellhead platforms. Recent technological developments, aimed at optimizing operations, include remotely operated subsea systems which remove the requirement for satellite platforms. This technology is also being used in deep water where platforms are unsuitable, and for marginal fields where platforms would be uneconomic. In these cases, floating systems – ships and semi-submersibles – 'service' the subsea wells on a regular basis.

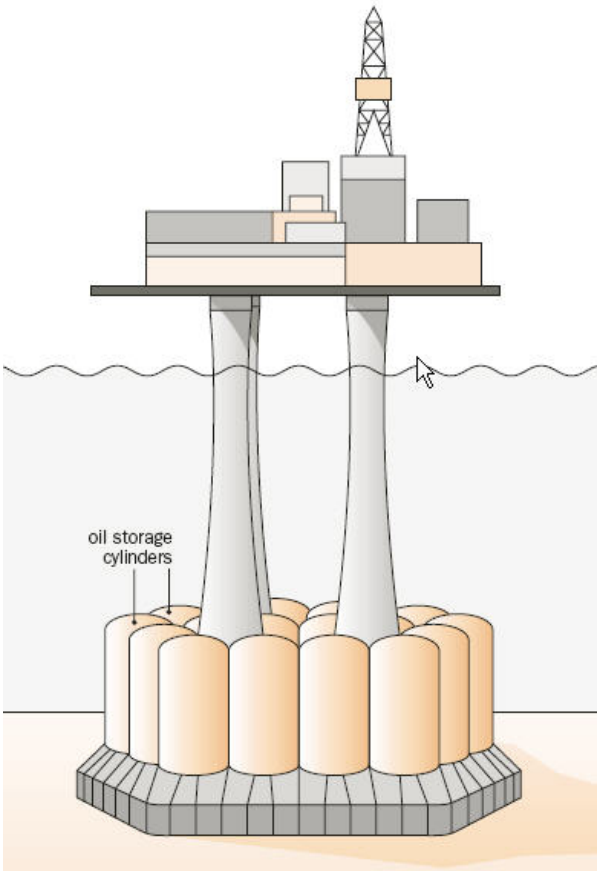


Figure 3-15: Concrete Gravity Platform

Source: Joint E&P Forum/ UNEP Technical Publication

Produced oil and gas may be exported by pipeline, trucks, tankers or rail tank cars. Gas-to-liquids is an area of technology development that allows natural gas to be converted to liquid. Gas is often exported, after liquefaction, as liquefied natural gas (LNG) using specially constructed tankers. Pipelines are constructed in a sequential process, including staking of the right-of-way (ROW) and pipeline centerline; ROW clearing and grading;

trenching (for buried pipeline); pipe laying, welding, and bending; field coating of welded joints; testing; lowering; trench backfilling; and ROW reinstatement. Pumps or compressors are used to transport liquids or gas from the oil and gas fields to downstream or export facilities. During commissioning, flow lines, pipelines, and associated facilities (e.g., block valves and meters, regulators and relief devices, pump stations, pigging stations, storage tanks) are filled with water and hydro tested to ensure integrity. Pipeline operation usually requires frequent inspections (ground and aerial surveillance, and facility inspections) and periodic ROW and facility maintenance. Production and pipeline operation is usually monitored and controlled from a central location through a supervisory control and data acquisition system (SCADA) which allows field operating variables to be monitored such as flow rate, pressure, and temperature and to open and close valves.

Recent advances in horizontal drilling have enhanced directional drilling as a means of concentrating operations at one site and reducing the 'footprint' on land of production operations (Figure 3-16) and the number of platforms offshore. The technology now enables access to a reservoir up to several kms from the drill rig, while technology is developing to permit even wider range. This further minimizes the 'footprint' by reducing the need for satellite wells. It also offers more flexibility in selecting a drill site, particularly where environmental concerns are raised.

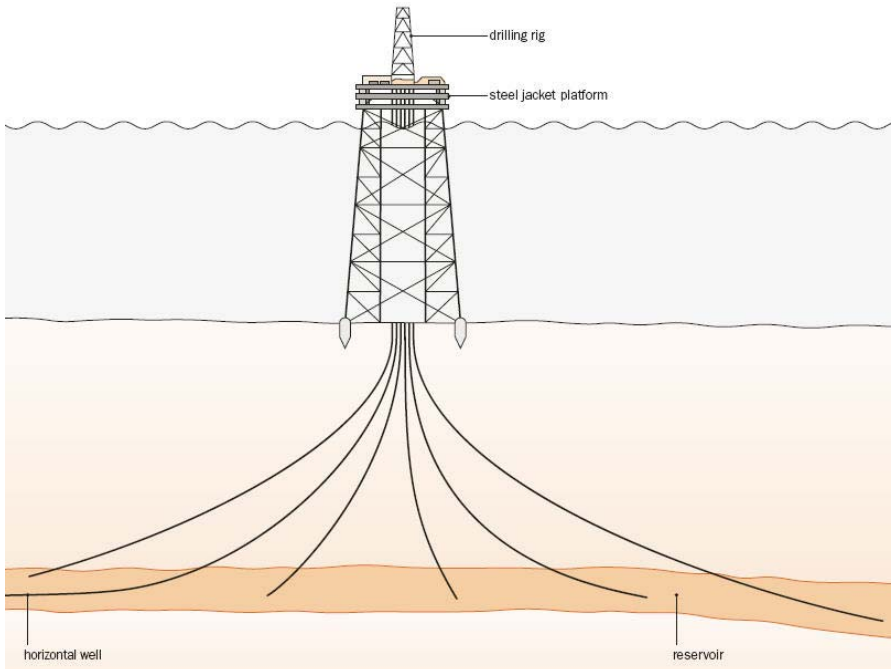


Figure 3-16: Directional Drilling

Source: Joint E&P Forum/ UNEP Technical Publication

3.2.1.4 Decommissioning and Abandonment

The decommissioning of onshore/ offshore facilities occurs at the end of their commercial life, typically after 20–40 years, *i.e.* when the reservoir is depleted or the production of hydrocarbons from that reservoir becomes unprofitable. It involves removal of buildings and equipment, restoration of the site to environmentally-sound conditions, implementation of measures to encourage site re-vegetation, and continued monitoring of

the site after closure. Planning for decommissioning is an integral part of the overall management process and should be considered at the beginning of the development during design, and is equally applicable to both onshore and offshore operations.

Parts of the onshore/offshore facilities, such as the aboveground facilities/ platforms located in the oil or gas field area and along the transmission lines, in case of onshore facility, are treated to remove hydrocarbons and other chemicals and wastes or contaminants and removed. Other components such as flow lines and pipelines/ production components are often left in place/ rendered safe and left in place to avoid environmental disturbances associated with removal. Wells are plugged and abandoned to prevent fluid migration within the wellbore or to the surface. The downhole equipment is removed and the perforated parts of the wellbore are cleaned of soil, scale, and other debris. The wellbore is then plugged. Fluids with an appropriate density are placed between the plugs to maintain adequate pressure. During this process, the plugs are tested to verify their correct placement and integrity. Finally, the casing is cut off below the surface and capped with a cement plug.

When oil wells are closed, considerable volume of oil still remains in place. Chemicals used during the production of oil are not totally consumed. The problems with abandonment of wells are as follows:

- Subsurface mitigation of methane and on surface oxidation by air
- Production of Hydrogen Sulphide by Sulfate reducers
- Subsidence of spent oil fields and consequent earth tremors
- Oxidation of light petroleum to form viscous air

By their nature, most exploration wells will be unsuccessful and will be de-commissioned after the initial one-to-three months of activity. It is, therefore, prudent to plan for this from the outset, and ensure minimal environmental disruption. Decommissioning and rehabilitation will subsequently be simplified.

Table 3-1: Summary of the Exploration and Production Process

Activity	Potential requirement on ground
Desk study: identifies area with favorable geological conditions	▪ None
Aerial survey: if favorable features revealed, then	▪ Low-flying aircraft over study area
Seismic survey: provides detailed information on geology	▪ Access to onshore sites and marine resource areas ▪ Possible onshore extension of marine seismic lines ▪ Onshore navigational beacons ▪ Onshore seismic lines ▪ Seismic operation camps
Exploratory drilling: verifies the presence or absence of a hydrocarbon reservoir and quantifies the reserves	▪ Access for drilling unit and supply units ▪ Storage facilities ▪ Waste disposal facilities ▪ Testing capabilities ▪ Accommodation
Appraisal: determines if the reservoir is economically feasible to develop	▪ Additional drill sites ▪ Additional access for drilling units and supply units

Activity	Potential requirement on ground
	▪ Additional waste disposal and storage facilities
Development and production: produces oil and gas from the reservoir through formation pressure, artificial lift, and possibly advanced recovery techniques, until economically feasible reserves are depleted	▪ Improved access, storage and waste disposal facilities ▪ Wellheads ▪ Flow lines ▪ Separation/treatment facilities ▪ Increased oil storage ▪ Facilities to export product ▪ Flares ▪ Gas production plant ▪ Accommodation, infrastructure ▪ Transport equipment
Decommissioning and rehabilitation may occur for each of above phases.	▪ Equipment to plug wells ▪ Equipment to demolish and remove installations ▪ Equipment to restore site
Source: Joint E&P Forum / UNEP Technical Publication	

3.2.2 Raw material inputs and pollution outputs

The various types of and sources of pollutants generated in this industry are listed below:

Table 3-2: List of Pollutants Generated

Liquid Effluents	Gaseous Emissions	Solid Waste
1. Drilling Stage		
Formation Water	Test-Flaring (Insignificant)	Drill – Cuttings
Wash waste from bit cuttings (mud treatment), auxiliary waste-sanitary	DG sets	Drilling mud
2. Production Stage		
Produced water	Associated gas	Oily sludge

3.2.2.1 Onshore

A. Air emissions

The main sources of continuous or non-continuous air emissions resulting from onshore activities include:

- Combustion sources from power and heat generation
- Use of compressors, pumps, and reciprocating engines (boilers, turbines, and other engines)
- Flaring and venting of hydrocarbons

- Fugitive emissions

Principal pollutants from these air emission sources include

- Nitrogen oxides
- Sulfur oxides
- Carbon monoxide and particulates
- Additional pollutants
  - Hydrogen sulfide (H_2S)
  - Volatile organic compounds (VOC) methane and ethane
  - Benzene
  - Ethyl benzene
  - Toluene, and xylenes (BTEX)
  - Glycols
  - Polycyclic aromatic hydrocarbons (PAHS).

Significant amount of toxic gas emissions from the site facilities and activities shall be quantified annually in accordance with nationally/internationally recognized methodologies and reporting procedures in order to reduce air emissions. Also, cost-effective options that are technically feasible shall be evaluated for reducing these emissions.

Air quality impacts should be estimated by the use of baseline air quality assessments and atmospheric dispersion models to establish potential ground level ambient air concentrations during facility design and operations planning as described in the General EHS Guidelines. These studies should ensure that no adverse impacts to human health and the environment result.

i. Exhaust gases

The most significant sources of exhaust gas emissions from onshore facilities are

- Combustion of gas or liquid fuels in turbines, boilers, compressors, pumps and other engines for power and heat generation
- Water injection
- Oil and gas export, *etc*.

Air emission specifications should be considered during all equipment selection and procurement. General EHS emission standards shall be followed for management of emission sources.

ii. Venting and flaring

Associated gas brought to the surface with crude oil during oil production is sometimes disposed off at onshore facilities by venting or flaring to the atmosphere. This practice is now widely recognized to be a waste of a valuable resource, as well as a significant source of green house gas (GHG) emissions. However, flaring or venting are also important safety measures used on onshore oil and gas facilities to ensure gas and other hydrocarbons are safely disposed in the event of an emergency, power or equipment failure, or other plant upset condition.

Measures consistent with the Global Gas Flaring and Venting Reduction Voluntary Standard (part of the World Bank Group's Global Gas Flaring Reduction Public-Private Partnership (GGFR program3) should be adopted when considering flaring and venting

options for onshore activities. The standard provides guidance on how to eliminate or achieve reductions in the flaring and venting of natural gas.

Continuous venting of associated gas is not considered a good practice and should be avoided. The associated gas stream should be routed to an efficient flare system, although continuous flaring of gas should be avoided if feasible alternatives are available. Before flaring is adopted, feasible alternatives for the use of the gas should be evaluated to the maximum extent possible and integrated into production design.

Alternative options may include gas utilization for on-site energy needs, export of the gas to a neighboring facility or to market, gas injection for reservoir pressure maintenance, enhanced recovery using gas lift, or gas for instrumentation. An assessment of alternatives should be adequately documented and recorded. If none of the alternative options are currently feasible, then measures to minimize flare volumes should be evaluated and flaring should be considered as an interim solution, with the elimination of continuous production associated gas flaring as the preferred goal. If flaring is necessary, continuous improvement of flaring through implementation of best practices and new technologies should be demonstrated.

The following pollution prevention and control measures should be considered for gas flaring:

- Implementation of source gas reduction measures to the maximum extent possible
- Use of efficient flare tips, and optimization of the size and number of burning nozzles
- Maximizing flare combustion efficiency by controlling and optimizing flare fuel / air stream flow rates to ensure the correct ratio of assist stream to flare stream
- Minimizing flaring from purges and pilots, without compromising safety, through measures including installation of purge gas reduction devices, flare gas recovery units, inert purge gas, soft seat valve technology where appropriate, and installation of conservation pilots
- Minimizing risk of pilot blow-out by ensuring sufficient exit velocity and providing wind guards
- Use of a reliable pilot ignition system
- Installation of high-integrity instrument pressure protection systems, wherever necessary, to reduce high-pressure events and to avoid or reduce flaring situations
- Minimizing liquid carry-over and entrainment in the gas flare stream with a suitable liquid separation system
- Minimizing flame lift off and / or flame lick
- Operating flare to control odor and visible smoke emissions (no visible black smoke)
- Locating flare at a safe distance from local communities and the workforce including workforce accommodation units
- Implementation of burner maintenance and replacement programs to ensure continuous maximum flare efficiency
- Metering flare gas

In event of an emergency or equipment breakdown, or plant upset conditions, excess gas should not be vented but should be sent to an efficient flare gas system. Emergency venting may be necessary under specific field conditions where flaring of the gas stream

is not possible, or where a flare gas system is not available, such as lack of sufficient hydrocarbon content in the gas stream to support combustion or lack of sufficient gas pressure to allow it to enter the flare system. Justification for excluding a gas flaring system should be fully documented before an emergency gas venting facility is considered.

To minimize flaring events as a result of equipment breakdowns and plant upsets, plant reliability should be high (>95%) and provision should be made for equipment sparing and plant turn down protocols.

Flaring volumes for new facilities should be estimated during the initial commissioning period so that fixed volume flaring targets can be developed. The volumes of gas flared for all flaring events should be recorded and reported.

iii. Fugitive emissions

Fugitive emissions at onshore facilities may be associated with cold vents, leaking pipes and tubing, valves, connections, flanges, packing, open-ended lines, pump seals, compressor seals, pressure relief valves, tanks or open pits / containments, and hydrocarbon loading and unloading operations.

Methods for controlling and reducing fugitive emissions should be considered and implemented in the design, operation, and maintenance of facilities. The selection of appropriate valves, flanges, fittings, seals, and packing should consider safety and suitability requirements as well as their capacity to reduce gas leaks and fugitive emissions. Additionally, leak detection and repair programs should be implemented. Vapor control units should be installed, as needed, for hydrocarbon loading and unloading operations.

Use of open vents in tank roofs should be avoided by installing pressure relief valves. Vapor control units should be installed, as needed, for the loading and unloading of ship tankers. Vapor processing systems may consist of different units, such as carbon adsorption, refrigeration, thermal oxidation, and lean oil absorption units. Additional guidance for the prevention and control of fugitive emissions from storage tanks are provided in the EHS Guidelines for Crude Oil and Petroleum Product Terminals.

iv. Well testing

During well testing, flaring of produced hydrocarbons should be avoided wherever practical and possible, and especially near local communities or in environmentally sensitive areas. Feasible alternatives should be evaluated for the recovery of hydrocarbon test fluids, while considering the safety of handling volatile hydrocarbons, for transfer to a processing facility or other alternative disposal options. An evaluation of disposal alternatives for produced hydrocarbons should be adequately documented and recorded.

If flaring is the only option available for the disposal of test fluids, only the minimum volume of hydrocarbons required for the test should be flowed and well test durations should be reduced to the extent practical. An efficient test flare burner head equipped with an appropriate combustion enhancement system should be selected to minimize incomplete combustion, black smoke, and hydrocarbon fallout. Volumes of hydrocarbons flared should be recorded.

B. Wastewaters

The General EHS Guidelines provide information on wastewater management, water conservation and reuse, along with wastewater and water quality monitoring programs. The guidance below is related to additional wastewater streams specific to the onshore oil and gas sector.

i. Produced water

Oil and gas reservoirs contain water (formation water) that is produced when brought to the surface during hydrocarbon production. The produced water stream can be one of the largest waste products, by volume, managed and disposed of by the onshore oil and gas industry. Produced water contains a complex mixture of inorganic (dissolved salts, trace metals, suspended particles) and organic (dispersed and dissolved hydrocarbons, organic acids) compounds, and in many cases, residual chemical additives (e.g., scale and corrosion inhibitors) that are added into the hydrocarbon production process.

Feasible alternatives for the management and disposal of produced water should be evaluated and integrated into production design. The main disposal alternatives may include injection into the reservoir to enhance oil recovery, and injection into a dedicated disposal well drilled to a suitable receiving subsurface geological formation. Other possible uses such as irrigation, dust control, or use by other industry, may be appropriate to consider if the chemical nature of the produced water is compatible with these options. Produced water discharges to surface waters or to land should be the last option considered and only if there is no other option available.

Produced water treatment technologies depend on the final disposal alternative selected and particular field conditions. Technologies to consider may include combinations of gravity and / or mechanical separation and chemical treatment, and may require a multistage system containing a number of technologies in series to meet injection or discharge requirements. Sufficient treatment system backup capability should be in place to ensure continual operation and or an alternative disposal method should be available.

To reduce the volume of produced water for disposal the following should be considered:

- Adequate well management during well completion activities to minimize water production
- Recompletion of high water producing wells to minimize water production
- Use of downhole fluid separation techniques, where possible, and water shutoff techniques, when technically and economically feasible
- Shutting in high water producing wells

To minimize environmental hazards related to residual chemical additives in the produced water stream where surface disposal methods are used, production chemicals should be selected carefully by taking into account their volume, toxicity, bioavailability, and bioaccumulation potential.

Disposal into evaporation ponds may be an option for produced waters. The construction and management measures for surface storage or disposal pits can also apply to produced water ponds.

ii. Hydrostatic testing waters

Hydrostatic testing of equipment and pipelines involves pressure testing with water to detect leaks and verify equipment and pipeline integrity. Chemical additives (corrosion inhibitors, oxygen scavengers, and dyes) may be added to the water to prevent internal corrosion or to identify leaks. For pipeline testing, test manifolds installed onto sections of newly constructed pipelines should be located outside the riparian zones and wetlands.

Water sourcing for hydro-testing purposes should not adversely affect the water level or flow rate of a natural water body, and the test water withdrawal rate (or volume) should not exceed 10% of the stream flow (or volume) of the water source. Erosion control measures and fish-screening controls should be implemented as necessary during water withdrawals at the intake locations.

The disposal alternatives for test waters following hydro testing include injection into a disposal well, if available or discharge to surface waters or land surface. If a disposal well is unavailable and discharge to surface waters or land surface is necessary, the following pollution prevention and control measures should be considered:

- Reduce the need for chemicals by minimizing the time that test water remains in the equipment or pipeline;
- If chemical use is necessary, carefully select chemical additives in terms of dose concentration, toxicity, biodegradability, bioavailability, and bioaccumulation potential;
- Conduct toxicity testing as necessary using recognized test methodologies. A holding pond may be necessary to provide time for the toxicity of the water to decrease.
- Holding ponds should meet the standards for surface storage or disposal pits as discussed below;
- Use the same hydro test water for multiple tests
- Hydrostatic test water quality should be monitored before use and discharge and should be treated to meet the discharge limits.
- If significant quantities of chemically treated hydrostatic test waters are required to be discharged to a surface water body, water receptors both upstream and downstream of the discharge should be monitored. Post-discharge chemical analysis of receiving water bodies may be necessary to demonstrate that no degradation of environmental quality has occurred
- If discharged into water, the volume and composition of the test water, as well as the stream flow or volume of the receiving water body, should be considered in selecting an appropriate discharge site to ensure that water quality will not be adversely affected outside of the defined mixing zone
- Use break tanks or energy dissipators (e.g., protective riprap, sheeting, tarpaulins) for the discharge flow
- Use sediment control methods (e.g., silt fences, sandbags or hay bales) to protect aquatic biota, water quality, and water users from the potential effect of discharge, such as increased sedimentation and reduced water quality
- If discharged to land, the discharge site should be selected to prevent flooding, erosion, or lowered agriculture capability of the receiving land. Direct discharge on cultivated land and land immediately upstream of community / public water intakes should be avoided

- Water discharge during cleaning pig runs and pretest water should be collected in holding tanks and should be discharged only after water-quality testing to ensure that it meets discharge criteria.

iii. Cooling water

Water conservation opportunities provided in the General EHS Guidelines should be considered for oil and gas facility cooling and heating systems. If cooling water is used, it should be discharged to surface waters in a location that allows maximum mixing and cooling of the thermal plume to ensure that the temperature is within 3 ^{o}Celsius (^{o}C) of ambient temperature at the edge of the defined mixing zone or within 100 m of the discharge point. If biocides and / or other chemical additives are used in the cooling water system, consideration should be given to residual effects at discharge using techniques such as risk based assessment.

iv. Other wastewaters

Wastewaters routinely generated at onshore oil and gas facilities include sewage waters, drainage waters, tank bottom water, fire water; equipment and vehicle wash waters, general oily water and non-process industrial wastewater like engine coolant and unused cement slurry. These wastewaters range from ones containing practically no contaminant (snowmelt, for example) to waters like cement slurries which clearly require treatment before they can be discharged or recycled.

Pollution prevention and treatment measures that should be considered for such wastewater should include:

- Sewage: Gray and black water from showers, toilets and kitchen facilities should be treated as described in the General EHS Guidelines.
- Drainage and stormwater: Separate drainage systems for drainage water from process areas that could be contaminated with oil (closed drains) and drainage water from non-process areas (open drains) should be available to the extent practical. All process areas should be bunded to ensure drainage water flows into the closed drainage system and that uncontrolled contaminated surface run-off is avoided. Drainage tanks and slop tanks should be designed with sufficient capacity for foreseeable operating conditions, and systems to prevent overfilling should be installed. Drip trays, or other controls, should be used to collect run-off from equipment that is not contained within a bunded area and the contents routed to the closed drainage system. Stormwater flow channels and collection ponds installed as part of the open drainage system should be fitted with oil / water separators. Separators may include baffle type or solid particle escaping plate type and should be regularly maintained. Stormwater runoff should be treated through oil / water separation system able to achieve an oil and grease concentration of 10 milligram per litre (mg/L). Additional guidance on the management of stormwater is provided in the General EHS Guideline.
- Tank bottom waters: The accumulation of tank bottom water should be minimized by regular maintenance of tank roofs and seals to prevent rainwater infiltration. Consideration should be given to routing these waters to the produced water stream for treatment and disposal, if available. Alternatively they should be treated as a hazardous waste and disposed in accordance with the facility waste management plan. Tank bottom sludges should also be periodically removed and recycled or disposed off as a hazardous waste.

- Firewater: Firewater from test releases should be directed to the facility drainage system.
- Wash water: Equipment and vehicle wash waters should be directed to the closed drainage system.
- General oily water: Oily water from drip trays and liquid slugs from process equipment and pipelines should be routed to the closed drainage system.

C. Waste management

Typical non-hazardous and hazardous wastes routinely generated at onshore facilities other than permitted effluents and emissions include general office and packaging wastes, waste oils, paraffins, waxes, oil contaminated rags, hydraulic fluids, used batteries, empty paint cans, waste chemicals and used chemical containers, used filters, fluorescent tubes, scrap metals, and medical waste, among others.

Waste materials should be segregated into non-hazardous and hazardous wastes for consideration for re-use, recycling, or disposal. Waste management planning should establish a clear strategy for wastes that will be generated including options for waste elimination, reduction or recycling or treatment and disposal, before any wastes are generated. A waste management plan documenting the waste strategy, storage (including facilities and locations) and handling procedures should be developed and should include a clear waste tracking mechanism to track waste consignments from the originating location to the final waste treatment and disposal location. Guidance for waste management of these typical waste streams is provided in the General EHS Guidelines.

Significant additional waste stream specific to onshore oil and gas development activities may include:

- Drilling fluids and drilled cuttings
- Produced sand
- Completion and well work-over fluids
- Naturally occurring radioactive materials (NORM)

i. Drilling fluids and drilled cuttings

The major source of pollution in the drilling system is the drilling mud and cuttings from the bit.

Drill mud: Drill mud (also called cutting mud) is a complex colloidal mixture of water, bentonitic clays, chemical additives, and trace amounts of oil from cuttings of the hydrocarbon-bearing zones. This mud serves several purposes in oil drilling as it is circulated down the inside of the rotating drill from the surface and backup the annular space between the drill pipe and the drilled hole. At the drill bit/rock interface, it cools and lubricates the cutting action. As it flows up the annular space, it lifts rock chips which can then be screened out at the surface. Most important, the column of mud creates hydrostatic pressure which keeps pressurized oil or gas from being expelled uncontrollably (a “blowout”).

Much of this drill mud is recycled, but after repeated use it picks up fine rock particles and water soluble subsurface minerals until it is no longer economically practical to recondition it. The colloidal mass can then be separated from the water either by centrifugal processes or by simply allowing it to settle in a pit. The remaining fluid is

then disposed off by deep injection. Much progress has been made in the last decade in the employment of low toxicity mud additives, which has enabled the EPA to issue NPDES permits for offshore discharges of treated mud and cuttings.

Drill cuttings: Drill cuttings are the pieces of rock and soil removed from the ground as a drill bit cuts a hole for a well. The volume of rock cuttings produced from drilling is primarily a function of the depth of the well and the diameter of the wellbore. It has been estimated that between 0.2 barrels and 2.0 barrels (8.4 and 84.0 gallons) of total drilling waste is produced for each vertical foot drilled (EPA, 1987).

Drilling operations also produce air emissions, such as exhaust from diesel engines and turbines that power the drilling equipment. The air pollutants from these devices will be those traditionally associated with combustion sources, including nitrogen oxides, particulates, ozone, and CO. Additionally, hydrogen sulfide may be released during the drilling process (EPA, 1992).

Some steps in the well completion process may produce waste. The most prominent is stimulation. Unused hydrochloric acid must be neutralized if acid stimulation is being used, and paraffins and any other dissolved materials brought to the surface from the formation must also be disposed. In addition, solid wastes such as waste cement and metal casing may remain from the casing process.

The primary functions of drilling fluids used in oil and gas field drilling operations include removal of drilled cuttings (rock chippings) from the wellbore and control of formation pressures. Other important functions include sealing permeable formations, maintaining wellbore stability, cooling and lubricating the drill bit, and transmitting hydraulic energy to the drilling tools and bit. Drilled cuttings removed from the wellbore and spent drilling fluids are typically the largest waste streams generated during oil and gas drilling activities. Numerous drilling fluid systems are available, but they can generally be categorized into one of two fluid systems:

- **Water-Based Drilling Fluids (WBDF):** The continuous phase and suspending medium for solids (or liquid) is water or a water miscible fluid. There are many WBDF variations, including gel, salt-polymer, salt-glycol, and salt-silicate fluids;
- **Non-Aqueous Drilling Fluids (NADF):** The continuous phase and suspending medium for solids (or liquid) is a water immiscible fluid that is oil-based, enhanced mineral oil-based, or synthetic-based.

Diesel-based fluids are also available, but the use of systems that contain diesel as the principal component of the liquid phase is not considered current good practice.

Typically, the solid medium used in most drilling fluids is barite (barium sulfate) for weight, with bentonite clays as a thickener. Drilling fluids also contain a number of chemicals that are added depending on the downhole formation conditions.

Drilling fluids are circulated downhole and routed to solids control system at the surface facilities where fluids can be separated from the cuttings so that they may be recirculated downhole leaving the cuttings behind for disposal. These cuttings contain a proportion of residual drilling fluid. The volume of cuttings produced will depend on the depth of the well and the diameter of the hole sections drilled. The drilling fluid is replaced when its rheological properties or density of the fluid can no longer be maintained or at the end of the drilling program. These spent fluids are then contained for reuse or disposal (NADFs are typically reused).

Feasible alternatives for the treatment and disposal of drilling fluids and drilled cuttings should be evaluated and included in the planning for the drilling program. Alternative options may include one, or a combination of, the following:

- Injection of the fluid and a mixture of cuttings into a dedicated disposal well
- Injection into the annular space of a well
- Storage in dedicated storage tanks or lined pits prior to treatment, recycling, and / or final treatment and disposal
- On-site or off-site biological or physical treatment to render the fluid and cuttings non-hazardous prior to final disposal using established methods such as thermal desorption in an internal thermal desorption unit to remove NADF for reuse, bioremediation, land farming, or solidification with cement and / or concrete. Final disposal routes for the non-hazardous cuttings solid material should be established, and may include use in road construction material, construction fill, or disposal through landfill including landfill cover and capping material where appropriate. In case of land farming it should be demonstrated that sub-soil chemical, biological, and physical properties are preserved and water resources are protected;
- Recycling of spent fluids back to the vendors for treatment and re-use.
- Consider minimizing volumes of drilling fluids and drilled cuttings requiring disposal by:
  - Use of high-efficiency solids control equipment to reduce the need for fluid change out and minimizing the amount of residual fluid on drilled cuttings;
  - Use of slim-hole multilateral wells and coiled tubing drilling techniques, when feasible, to reduce the amount of fluids and cuttings generated.
- Pollution prevention and control measures for spent drilling fluids and drilled cuttings should include:
- Minimizing environmental hazards related to residual chemicals additives on discharged cuttings by careful selection of the fluid system.
- Careful selection of fluid additives taking into account the technical requirements, chemical additive concentration, toxicity, bioavailability and bioaccumulation potential;
- Monitoring and minimizing the concentration of heavy metal impurities (mainly mercury and cadmium) in barite stock used in the fluid formulation.
- The construction and management measures for surface storage or disposal pits should be applied to cuttings and drilling fluid pits. For drilling pits, pit closure should be completed as soon as practical, but no longer than 12 months, after the end of operations. If the drilling waste is to be buried in the pit following operations (the Mix-Bury-Cover disposal method), the following minimum conditions should be met:
- The pit contents should be dried out as far as possible
- If necessary, the waste should be mixed with an appropriate quantity of subsoil (typically three parts of subsoil to one part of waste by volume)
- A minimum of one meter of clean subsoil should be placed over the mix
- Top soil should not be used but it should be placed over the sub-soil to fully reinstate the area.

- The pit waste should be analyzed and the maximum lifetime loads should be calculated. A risk-based assessment may be necessary to demonstrate that internationally recognized thresholds for chemical exposure are not exceeded

ii. Produced sand

Produced sand originating from the reservoir is separated from the formation fluids during hydrocarbon processing. The produced sand can be contaminated with hydrocarbons, but the oil content can vary substantially depending on location, depth, and reservoir characteristics. Well completion should aim to reduce the production of sand at source using effective downhole sand control measures.

Produced sand should be treated as an oily waste, and may be treated and disposed of along with other oil contaminated solid materials (e.g., with cuttings generated when NADFs are used or with tank bottom sludges).

If water is used to remove oil from produced sand, it should be recovered and routed to an appropriate treatment and disposal system (e.g., the produced water treatment system when available).

iii. Completion of well work-over fluids

Completion and well work-over fluids (including intervention and service fluids) can typically include weighted brines, acids, methanol and glycols, and other chemical systems. These fluids are used to clean the wellbore and stimulate the flow of hydrocarbons, or simply used to maintain downhole pressure. Once used these fluids may contain contaminants including solid material, oil, and chemical additives. Chemical systems should be selected with consideration of their volume, toxicity, bioavailability, and bioaccumulation potential. Feasible disposal options should be evaluated for these fluids. Alternative disposal options may include one, or a combination of, the following:

- Collection of fluids if handled in closed systems and shipping to the original vendors for recycling
- Injection to a dedicated disposal well, where available
- Inclusion as part of the produced water waste stream for treatment and disposal. Spent acids should be neutralized before treatment and disposal
- On-site or off-site biological or physical treatment at an approved facility in accordance with the waste management plan.

iv. Naturally occurring radioactive materials (NORM)

Depending on the field reservoir characteristics, NORMs may precipitate as scale or sludges in process piping and production vessels. Where NORM is present, a NORM management program should also be developed so that appropriate handling procedures are followed. If removal of NORM is required for occupational health reasons, disposal options may include:

- canister disposal during well abandonment;
- deep well or salt cavern injection;
- injection into the annular space of a well or disposal to landfill in sealed containers.

Sludge, scale, or NORM-impacted equipment should be treated, processed, or isolated so that potential future human exposures to the treated waste would be within internationally

accepted risk-based limits. Recognized industrial practices should be used for disposal. If waste is sent to an external facility for disposal, the facility must be licensed to receive such waste.

v. Hazardous materials

General guidance for the management of hazardous materials is provided in the General EHS Guidelines. The following additional principles should be followed for chemicals used in the onshore oil and gas sector:

- Use chemical hazard assessment and risk management techniques to evaluate chemicals and their effects. Selected chemicals should have been tested for environmental hazards;
- Select chemicals with least hazard and lowest potential environmental and / or health impact, whenever possible;
- Use of Ozone Depleting Substances should be avoided.

D. Noise

Oil and gas development activities can generate noise during all phases of development including the seismic surveys, construction activities, drilling and production, aerial surveys and air or road transportation. During operations, the main sources of noise and vibration pollution are likely to emanate from flaring and rotating equipment. Noise sources include flares, vents, pumps, compressors, generators, and heaters. Noise prevention and control measures are described in the General EHS Guidelines, along with the recommended daytime and night time noise level guidelines for urban or rural communities.

Noise impacts should be estimated by the use of baseline noise assessments for developments close to local human populations. For significant noise sources, such as flare stacks at permanent processing facilities, noise dispersion models should be conducted to establish the noise level guidelines can be met and to assist in the design of facility siting, stack heights, engineered sound barriers, and sound insulation on buildings.

Field-related vehicle traffic should be reduced as far as possible and access through local communities should be avoided when not necessary. Flight access routes and low flight altitudes should be selected and scheduled to reduce noise impacts without compromising aircraft and security. The sound and vibration propagation arising from seismic operations may result in impacts to human populations or to wildlife. In planning seismic surveys, the following should be considered to minimize impacts:

- Minimize seismic activities in the vicinity of local population wherever possible
- Minimize simultaneous operations on closely spaced survey lines
- Use the lowest practicable vibrator power levels
- Reduce operation times, to the extent practical
- When shot-hole methods are employed, charge size and hole depth should be appropriately selected to reduce noise levels. Proper back-fill or plugging of holes will also help to reduce noise dispersion;
- Identify areas and time periods sensitive to wildlife such as feeding and breeding locations and seasons and avoid them when possible;

- If sensitive wildlife species are located in the area, monitor their presence before the onset of noise creating activities, and throughout the seismic program. In areas where significant impacts to sensitive species are anticipated, experienced wildlife observers should be used. Slowly buildup activities in sensitive locations.

E. Terrestrial impacts and project footprint

Project footprints resulting from exploration and construction activities may include seismic tracks, well pads, temporary facilities, such as workforce base camps, material (pipe) storage yards, workshops, access roads, airstrips and helipads, equipment staging areas, and construction material extraction sites (including borrow pits and quarries).

Operational footprints may include well pads, permanent processing treatment, transmission and storage facilities, pipeline right-of-way corridors, access roads, ancillary facilities, communication facilities (e.g., antennas), and power generation and transmission lines. Impacts may include loss of or damage to, terrestrial habitat, creation of barriers to wildlife movement, soil erosion, and disturbance to water bodies including possible sedimentation, the establishment of non-native invasive plant species and visual disturbance. The extent of the disturbance will depend on the activity along with the location and characteristics of the existing vegetation, topographic features and waterways.

The visual impact of permanent facilities should be considered in design so that impacts on the existing landscape are minimized. The design should take advantage of the existing topography and vegetation, and should use low profile facilities and storage tanks if technically feasible and if the overall facility footprint is not significantly increased. In addition, consider suitable paint color for large structures that can blend with the background. General guidance on minimizing the project footprint during construction and decommissioning activities is provided in the General EHS Guidelines.

Additional prevention and control measures to minimize the footprint of onshore oil and gas developments may include the following:

- Establish all facilities in locations that avoid critical terrestrial and aquatic habitat and plan construction activities to avoid sensitive times of the year;
- Minimize land requirements for aboveground permanent facilities;
- Minimize areas to be cleared. Use hand cutting where possible, avoiding the use of heavy equipment such as bulldozers, especially on steep slopes, water and wetland crossings, and forested and ecologically sensitive areas;
- Use a central processing / treatment facility for operations, when practical;
- Minimize well pad size for drilling activities and satellite / cluster, directional, extended reach drilling techniques should be considered, and their use maximized in sensitive locations;
- Avoid construction of facilities in a floodplain, whenever practical, and within a distance of 100 m of the normal high-water mark of a water body or a water well used for drinking or domestic purposes;
- Consider the use of existing utility and transport corridors for access roads and pipeline corridors to the extent possible;
- Consider the routing of access roads to avoid induced impacts such as increased access for poaching;

- Minimize the width of a pipeline ROW or access road during construction and operations as far as possible;
- Limit the amount of pipeline trench left open during construction at any one time. Safety fences and other methods to prevent people or animals from falling into open trenches should be constructed in sensitive locations and within 500 m of human populations. In remote areas, install wildlife escape ramps from open trenches (typically every 1km where wildlife is present);
- Consider use of animal crossing structures such as bridges, culverts, and over crossings, along pipeline and access road rights-of-way;
- Bury pipelines along the entire length to a minimum of 1 m to the top-of-pipe, wherever this is possible;
- Carefully consider all of the feasible options for the construction of pipeline river crossings including horizontal directional drilling;
- Clean-up and fully reinstate following construction activities (including appropriate revegetation using native plant species following construction activities) the pipeline right-of-way and temporary sites such as workforce accommodation camps, storage yards, access roads, helipads and construction workshops, to the pre-existing topography and drainage contours;
- Reinstate off-site aggregate extraction facilities including borrow pits and quarries (opened specifically for construction or extensively used for construction);
- Implement repair and maintenance programs for reinstated sites;
- Consider the implementation of low impact seismic techniques (e.g. minimize seismic line widths (typically no wider than 5 m), limit the line of sight along new cut lines in forested areas (approximately 350 m));
- Consider shot-hole methods in place of vibroseis where preservation of vegetation cover is required and when access is limited. In areas of low cover (e.g. deserts, or tundra with snow cover in place), vibroseis machinery should be selected, but soft soil locations should be carefully assessed to prevent excessive compaction;
- Install temporary and permanent erosion and sediment control measures, slope stabilization measures, and subsidence control and minimization measures at all facilities, as necessary;
- Regularly maintain vegetation growth along access roads and at permanent above ground facilities, and avoid introduction of invasive plant species. In controlling vegetation use biological, mechanical and thermal vegetation control measures and avoid the use of chemical herbicides as much as possible. If it is demonstrated that the use of herbicides is required to control vegetation growth along access roads or at facilities, then personnel must be trained in their use. Herbicides that should be avoided include those listed under the World Health Organization recommended Classification of Pesticides by Hazard Classes 1a and 1b, the World Health Organization recommended Classification of Pesticides by Hazard Class II (except under conditions as noted in IFC Performance Standard 3: Pollution Prevention and Abatement;7), and Annexes A and B of the Stockholm Convention, except under the conditions noted in the convention.8

F. Spills

Spills from onshore facilities, including pipelines, can occur due to leaks, equipment failure, accidents, and human error or as a result of third party interference. Guidelines

for release prevention and control planning are provided in the General EHS Guidelines, including the requirement to develop a spill prevention and control plan.

Additional spill prevention and control measures specific to onshore oil and gas facilities include:

- Conduct a spill risk assessment for the facilities and design, drilling, process, and utility systems to reduce the risk of major uncontained spills;
- Ensure adequate corrosion allowance for the lifetime of the facilities or installation of corrosion control and prevention systems in all pipelines, process equipment, and tanks;
- Install secondary containment around vessels and tanks to contain accidental releases;
- Install shutdown valves to allow early shutdown or isolation in the event of a spill;
- Develop automatic shutdown actions through an emergency shutdown system for significant spill scenarios so that the facility may be rapidly brought into a safe condition;
- Install leak detection systems. On pipelines consider measures such as telemetry systems, Supervisory Control and Data Acquisition (SCADA9), pressure sensors, shut-in valves, and pump-off systems,
- Develop corrosion maintenance and monitoring programs to ensure the integrity of all field equipment. For pipelines, maintenance programs should include regular pigging to clean the pipeline, and intelligent pigging should be considered as required;
- Ensure adequate personnel training in oil spill prevention, containment, and response;
- Ensure spill response and containment equipment is deployed or available for a response.

All spills should be documented and reported. Following a spill, a root cause investigation should be carried out and corrective actions should be undertaken to prevent reoccurrence. A Spill Response Plan should be prepared, and the capability to implement the plan should be in place. The Spill Response Plan should address potential oil, chemical, and fuel spills from facilities, transport vehicles, loading and unloading operations, and pipeline ruptures. The plan should include:

- A description of the operations, site conditions, logistic support and oil properties
- Identification of persons responsible for managing spill response efforts, including their authority, roles and contact details
- Documentation of cooperative measures with government agencies as appropriate
- Spill risk assessment, defining expected frequency and size of spills from different potential release sources
- Oil spill trajectory in potentially affected surface water bodies, with oil fate and environmental impact prediction for a number of credible most-probable spill simulations (including a worst case scenario, such as blowout from an oil well) using an adequate and internationally recognized computer model
- Clear demarcation of spill severity, according to the size of the spill using a clearly defined Tier I, Tier II and Tier III approach
- Strategies and equipment for managing Tier I spills at a minimum

- Arrangements and procedures to mobilize external resources for responding to larger spills and strategies for deployment
- Full list, description, location, and use of on-site and off-site response equipment and the response time estimates for deploying equipment
- Sensitivity mapping of the environment at risk. Information should include: soil types; groundwater and surface water resources; sensitive ecological and protected areas; agricultural land; residential, industrial, recreational, cultural, and landscape features of significance; seasonal aspects for relevant features, and oil spill response types to be deployed
- Identification of response priorities, with input from potentially affected or concerned parties
- Clean up strategies and handling instructions for recovered oil, chemicals, fuels or other recovered contaminated materials, including their transportation, temporary storage, and treatment / disposal

3.2.2.2 Offshore

A. Air emissions

The main sources of air emissions (continuous or non-continuous) resulting from offshore activities include: combustion sources from power and heat generation, and the use of compressors, pumps, and reciprocating engines (boilers, turbines, and other engines); emissions resulting from flaring and venting of hydrocarbons; and fugitive emissions.

Principal pollutants from these sources include NOx, SOx, CO_2, CO, and particulates. Additional pollutants can include: hydrogen sulfide (H_2S); volatile organic compounds (VOC) methane and ethane; benzene, ethyl benzene, toluene, and xylenes (BTEX); glycols; and polycyclic aromatic hydrocarbons (PAHs).

i. Exhaust gases

Exhaust gas emissions produced by the combustion of gas or liquid fuels in turbines, boilers, compressors, pumps and other engines for power and heat generation, or for water injection or oil and gas export, can be the most significant source of air emissions from offshore facilities.

ii. Venting and flaring

Associated gas brought to the surface with crude oil during oil production is sometimes disposed off at onshore/ offshore facilities by venting or flaring to the atmosphere. This practice is now widely recognized to be a waste of a valuable resource, as well as a significant source of GHG emissions. All efforts should be made to keep flaring to the minimum and only for technical reasons ad safety. Flares are also a problem in terms of aesthetics.

iii. Fugitive emissions

Fugitive emissions at onshore facilities may be associated with cold vents, leaking pipes and tubing, valves, connections, flanges, packings, open-ended lines, pump seals, compressor seals, pressure relief valves, tanks or open pits / containments, and hydrocarbon loading and unloading operations.

iv. Well testing

During well testing, flaring of produced hydrocarbons should be avoided wherever practical and possible, and especially near local communities or in environmentally sensitive areas. Feasible alternatives should be evaluated for the recovery of hydrocarbon test fluids, while considering the safety of handling volatile hydrocarbons, for transfer to a processing facility or other alternative disposal options. An evaluation of disposal alternatives for produced hydrocarbons should be adequately documented and recorded.

If flaring is the only option available for the disposal of test fluids, only the minimum volume of hydrocarbons required for the test should be flowed and well test durations should be reduced to the extent practical. An efficient test flare burner head equipped with an appropriate combustion enhancement system should be selected to minimize incomplete combustion, black smoke, and hydrocarbon fallout. Volumes of hydrocarbons flared should be recorded.

B. Wastewaters

i. Produced water

Produced water, water produced in association with crude oil, is by far the largest waste stream in most oil fields, accounting for up to 95 percent of total wastes. It is composed of a complex mixture of inorganic (dissolved salts, trace metals, suspended particles) and organic (dispersed and dissolved hydrocarbons, organic acids) compounds, and in many cases, residual chemical additives (e.g. scale and corrosion inhibitors) that are added into the hydrocarbon production process.

In wells nearing the end of their productive lives, water can comprise 98%of the material brought to the surface (Wiedeman, 1996). The American Petroleum Institute estimates that over 15 billion barrels of water are produced annually. This is nearly eight barrels of water for every barrel of oil produced. Natural gas wells typically produce much lower volumes of water than oil wells, with the exception of certain types of gas resources such as Coal Bed Methane (CBM) or Devonian/Antrim shales (API, 1997).

Although many petroleum components are separated from the water easily, some components and impurities are water-soluble and difficult to remove. Some substances may be found in high concentrations, including chloride, sodium, calcium, magnesium and potassium. Others found are:

- Organic compounds: benzene, naphthalene, toluene, phenanthrene, bromodichloromethane, and pentachlorophenol;
- Inorganics: lead, arsenic, barium, antimony, sulfur, and zinc;
- Radionuclides: uranium, radon, and radium (EPA, 1992).

It should be noted that concentrations of these pollutants vary considerably depending on the location of the well and the extent of treatment of the water. Geography can be a key factor in whether a substance may exist in produced water. For example, radionuclides are found only in some areas of the country.

ii. Hydrostatic testing waters

Hydrostatic testing of offshore equipment and marine pipelines involves pressure testing with water (typically filtered seawater, unless equipment specifications do not allow it) to

verify equipment and pipeline integrity. Chemical additives (corrosion inhibitors, oxygen scavengers, and dyes) may be added to the water to prevent internal corrosion or to identify leaks. In managing hydrotest waters, the following pollution prevention and control measures should be considered:

- Minimizing the volume of hydrotest water offshore by testing equipment at an onshore site before the equipment is loaded onto the offshore facilities;
- Using the same water for multiple tests
- Reducing the need for chemicals by minimizing the time that test water remains in the equipment or pipeline
- Careful selection of chemical additives in terms of dose concentration, toxicity, biodegradability, bioavailability, and bioaccumulation potential
- Sending offshore pipeline hydrotest water to shore facilities for treatment and disposal, where practical.

If discharge of hydrotest waters to the sea is the only feasible alternative for disposal, a hydrotest water disposal plan should be prepared that considers points of discharge, rate of discharge, chemical use and dispersion, environmental risk, and monitoring. Hydrotest water disposal into shallow coastal waters should be avoided.

iii. Cooling waters

Anti-foulant chemical dosing to prevent marine fouling of offshore facility cooling water systems should be carefully considered. Available alternatives should be evaluated and, where practical, the seawater intake depth should be optimized to reduce the need for use of chemicals. Appropriate screens should be fitted to the seawater intake if safe and practical. The cooling water discharge depth should be selected to maximize mixing and cooling of the thermal plume to ensure that the temperature is within $3^{o}C$ of ambient seawater temperature at the edge of the defined mixing zone or within 100 m of the discharge point.

iv. Desalination brine

Operators should consider mixing desalination brine from the potable water system with the cooling water or sewage water discharge. If mixing with other discharge waste streams is not feasible, the discharge location should be carefully selected w.r.t. potential environmental impacts.

v. Other wastewater

Wastewater routinely generated at offshore facilities is listed below:

- Sewage: Gray and black water from showers, toilets, and kitchen facilities
- Food waste: Organic (food) waste from the kitchen
- Storage displacement Water: Water pumped in and out of storage during loading and off-loading operations
- Bilge water: Bilge water from machinery spaces in offshore facilities and support vessels
- Deck drainage water: Drainage water generated from precipitation, sea spray, or routine operations, such as deck and equipment cleaning and fire drills,

C. Waste management

Typical non-hazardous and hazardous wastes routinely generated at offshore facilities include general office and packaging waste, waste oils, oil contaminated rags, hydraulic fluids, used batteries, empty paint cans, waste chemicals and used chemical containers, used filters, fluorescent tubes, scrap metals, and medical waste, *etc*. These waste materials should be segregated offshore into non-hazardous and hazardous wastes at a minimum, and shipped to shore for re-use, recycling, or disposal. A waste management plan for the offshore facility should be developed that contains a clear waste tracking mechanism to track waste consignments from the originating location offshore to the final waste treatment and disposal location onshore. Efforts should be made to eliminate, reduce, or recycle wastes at all times. Guidance for waste management of these typical waste streams onshore is provided in the General EHS Guidelines. Significant additional waste streams specific to offshore development activities include:

- Drilling fluids and drilled cuttings
- Produced sand
- Completion and well work-over fluids
- NORM

i. Drilling fluids and drilled cuttings

The primary functions of drilling fluids used in oil and gas field drilling operations include removal of drilled cuttings (rock chippings) from the wellbore and control of formation pressures. Other important functions include sealing permeable formations, maintaining wellbore stability, cooling and lubricating the drill bit, and transmitting hydraulic energy to the drilling tools and bit. Drilled cuttings removed from the wellbore and spent drilling fluids are typically the largest waste streams generated during oil and gas drilling activities.

Various drilling fluids are available, but they can generally be categorized into one of two fluid systems:

- WBDF: Fluids where the continuous phase and suspending medium for solids is seawater or a water miscible fluid. There are many WBDF variations, including gel , salt-polymer , salt-glycol and salt-silicate fluids;
- NADF: The continuous phase and suspending medium for solids is a water immiscible fluid that is oil-based, enhanced mineral oil-based, or synthetic-based.

Diesel-based fluids are also available, but the use of systems that contain diesel as the principal component of the liquid phase is not considered current good practice for offshore drilling programs and should be avoided.

Typically, the solid medium used in most drilling fluids is barite (barium sulfate) for weight, with bentonite clays as a thickener. Drilling fluids also contain a number of chemicals that are added depending on the downhole formation conditions.

Drilling fluids are either circulated downhole with direct loss to the seabed along with displaced cuttings, particularly while drilling well sections nearest to the surface of the seabed, or are recirculated to the offshore facility where they are routed to a solids control system. In the solids control system, the drilling fluids are separated from the cuttings so that they may be recirculated downhole leaving the cuttings behind for disposal. These cuttings contain a proportion of residual drilling fluid. The volume of cuttings produced depends on the depth of the well and the diameter of the hole sections drilled.

The drilling fluid is replaced when its rheological properties or density of the fluid can no longer be maintained or at the end of the drilling program. These spent fluids are then contained for reuse or disposal. Disposal of spent NADF by discharge to the sea must be avoided. Instead, they should be transferred to shore for recycling or treatment and disposal.

Feasible alternatives for the disposal of spent WBDF and drilled cuttings from well sections drilled with either WBDF or NADF should be evaluated. Options include injection into a dedicated disposal well offshore, injection into the annular space of a well, containment and transfer to shore for treatment and disposal and, when there is no other option available, discharge to sea.

When discharge to sea is the only alternative, a drilled cuttings and fluid disposal plan should be prepared taking into account cuttings and fluid dispersion, chemical use, environmental risk, and necessary monitoring. Discharge of cuttings to sea from wells drilled with NADF should be avoided. If discharge is necessary, cuttings should be treated before discharge. Guidance for the treatment and disposal of fluids and cuttings shipped to shore are provided in the EHS Guidelines for Onshore Oil and Gas Development.

Pollution prevention and control measures to consider prior to the discharge of spent drilling fluids and drilled cuttings should include:

- Minimizing environmental hazards related to residual chemicals additives on discharged cuttings by careful selection of the fluid system. WBDFs should be selected whenever appropriate
- Careful selection of fluid additives taking into account their concentration, toxicity, bioavailability and bioaccumulation potential
- Use of high efficiency solids control equipment to reduce the need for fluid change out and minimizing the amount of residual fluid on drilled cuttings
- Use directional drilling (horizontal and extended reach) techniques to avoid sensitive surface areas and to gain access to the reservoir from less sensitive surface areas
- Use of slim-hole multilateral wells and coiled tubing drilling techniques, when feasible, to reduce the amount of fluids and cuttings

Drilling fluids to be discharged to sea (including as residual material on drilled cuttings) are subject to tests for toxicity, barite contamination, and oil content. All discharges should be made via a caisson at least 15 m below the sea surface.

ii. Produced sand

Produced sand originating from the reservoir is separated from the formation fluids during hydrocarbon processing. The produced sand can be contaminated with hydrocarbons, but the oil content can vary substantially depending on location, depth, and reservoir characteristics. Well completion should aim to reduce the production of sand at source using effective downhole sand control measures. Whenever practical, produced sand removed from process equipment should be transported to shore for treatment and disposal, or routed to an offshore injection disposal well if available. Discharge to sea is not considered to be current good practice. If discharge to sea is the only demonstrable feasible option then the discharge should meet some guideline values.

iii. Completion and well work-over fluids

Completion and well work-over fluids (including intervention fluids and service fluids) can typically include weighted brines or acids, methanol and glycols, and many other chemical systems. These fluids are used to clean the wellbore and stimulate the flow of hydrocarbons, or simply used to maintain downhole pressure. Once used these fluids may contain contaminants including solid material, oil, and chemical additives. Feasible disposal options should be considered, where practical, including:

- Collection of fluids if handled in closed systems and shipping to shore to the original vendors for recycling
- Injection in an available injection disposal well, where available
- Shipping to shore for treatment and disposal
- If discharge to sea is the only demonstrated feasible option:
- Chemical systems should be selected in terms of their concentration, toxicity, bioavailability and bioaccumulation potential;
- Consideration should be given to routing these fluids to the produced water stream for treatment and disposal, if available;
- Spent acids should be neutralized before treatment and disposal;
- The fluids should meet the discharge levels in Table 1 in Section 2 of this Guideline.

iv. Naturally occurring radioactive materials

Naturally Occurring Radioactive Material, or "NORM," is produced in solution with oil field brines and deposited as scale on the inside of oil field vessels and piping. Its radioactivity (rated as "low specific activity" by the Nuclear Regulatory Commission) poses a hazard if it is inhaled as a dry dust during vessel and pipe cleaning or repair. Recycling of this material is impeded by the lack of safe exposure levels.

Depending on the field reservoir characteristics, NORMs may precipitate as scale or sludges in process piping and production vessels. Where NORM is present, a NORM management program should be developed so that appropriate handling procedures are followed. If removal of NORM is required for occupational health reasons, disposal options may include: canister disposal during well abandonment; injection into the annular space of a well; shipping to shore for disposal to landfill in sealed containers; and, depending on the type of NORM and when there is no other option available, discharge to sea with the facility drainage.

Sludge, scale, or NORM-impacted equipment should be treated, processed, or isolated so that potential future human exposures to the treated waste would be within internationally accepted risk-based limits. Recognized industrial practices should be used for disposal. If waste is sent to an external onshore facility for disposal, the facility must be licensed to receive such waste.

v. Hazardous materials management

There are many hazardous materials used in offshore oil and gas operations. General guidance for the management of hazardous materials is provided in the General EHS Guidelines.

The following additional principles should be followed for offshore chemicals:

- Use of chemical hazard assessment and risk management techniques to evaluate chemicals and their effects
- Selected chemicals should be previously tested for environmental hazards
- Offshore drilling and production chemicals should be selected based on the OSPAR4 Harmonized Offshore
- Chemical Notification Format (HOCNF) or similar internationally recognized system
- Chemicals with least hazard and lowest potential environmental impact, and lowest potential health impact, should be selected, whenever possible
- Use of chemicals suspected to cause taint or known endocrine disruptors should be avoided
- Use of Ozone-depleting Substances should be avoided
- Chemicals known to contain heavy metals, other than in trace quantities, should be avoided

D. Noise

Oil and gas development activities generating marine noise include seismic operations, drilling and production activities, offshore and nearshore structural installation (especially pile driving) and construction activities, and marine traffic. Noise from offshore activities (especially from seismic operations) can temporarily affect fish and marine mammals. Recommended measures to reduce the risk of noise impact to marine species include:

- Identifying areas sensitive for marine life such as feeding, breeding, calving, and spawning areas
- Planning seismic surveys and offshore construction activities to avoid sensitive times of the year
- Identifying fishing areas and reducing disturbance by planning seismic surveys and construction activities at less productive times of the year, where possible
- Maximize the efficiency of seismic surveys to reduce operation times, where possible
- If sensitive species are anticipated in the area, monitor their presence before the onset of noise creating activities, and throughout the seismic program or construction. In areas where significant impacts to sensitive species are anticipated, experienced observers should be used
- When marine mammals are observed congregating close to the area of planned activities, seismic start up or construction should begin at least 500 m away
- If marine mammals are sighted within 500 m of the proposed seismic array or construction area, start up of seismic activities or construction should be postponed until they have moved away, allowing adequate time after the last sighting
- Soft-start procedures, also called ramp-up or slow buildup, should be used in areas of known marine mammal activity. This involves a gradual increase in sound pressure to full operational levels
- The lowest practicable power levels should be used throughout the seismic surveys, and their use should be documented

- Methods to reduce and/or baffle unnecessary high frequency noise produced by air guns or other acoustic energy sources should be used, where possible

E. Spills

Spills from offshore facilities can occur due to leaks, equipment failure, accidents, or human error. Guidelines for release prevention and control planning are provided in the General EHS Guidelines, including the requirement to develop a spill prevention and control plan. Additional spill prevention and control measures specific to offshore oil and gas facilities include:

- Conducting a spill risk assessment for offshore facilities and support vessels;
- Design of process, utility, and drilling systems to reduce the risk of major uncontained spills;
- Install valves, including subsea shutdown valves, to allow early shutdown or isolation in the event of an emergency;
- Ensure adequate corrosion allowance for the lifetime of the facilities and / or installation of corrosion control and prevention systems in all pipelines, process equipment, and tanks;
- Develop maintenance and monitoring programs to ensure the integrity of well field equipment. For export pipelines, maintenance programs should include regular pigging to clean the pipeline, and intelligent pigging should also be considered as required;
- Install leak detection systems. Use of sub-sea pipelines measures, such as telemetry systems, SCADA6 systems, pressure sensors, shut-in valves, and pump-off systems, as well as normally unattended installations (unmanned) facilities to ensure rapid detection of loss of containment;
- For facilities with potentially significant releases, install an Emergency Shutdown System that initiates automatic shutdown actions to bring the offshore facility to a safe condition
- Adequate personnel training in oil spill prevention, containment and response.
- Ensure spill response and containment equipment is deployed or available as necessary for response

All spills should be documented and reported. Following a spill, a root cause investigation should be carried out and corrective action taken. A Spill Response Plan is required, along with the capability to implement the plan. The Spill Response Plan should address potential oil, chemical, and fuel spills from offshore facilities, support vessels including tankers, and pipeline ruptures. The plan should also include:

- A description of operations, site conditions, current and wind data, sea conditions and water depth, and logistical support;
- Identification of persons responsible for managing spill response efforts, their responsibility, authority, roles and contact details;
- Cooperative measures with government agencies, if appropriate;
- Spill risk assessment, defining expected frequency and size of spills from different potential release sources; including assessment of foreseeable scenarios;

- Oil spill trajectory modeling with oil fate and environmental impact prediction for a number of spill simulations (including worst case scenario, such as blowout from an oil well) using an adequate and internationally recognized computer model with the ability to input local current and wind data;
- Clear demarcation of spill severity, according to the size of the spill using a clearly defined Tier I, Tier II and Tier III approach;
- Strategies for managing Tier I spills at a minimum, from the offshore installation and support vessels;
- Arrangements and procedures to mobilize external resources for responding to larger spills and strategies for deployment;
- Full list, description, location, and use of on-site and off-site response equipment, and the response times for deployment;
- Strategies for containment and recovery of floating oil, including use (and limitations) of chemical dispersants;
- Maps identifying sensitive ecological areas (seasonal / monthly) prepared using sensitivity mapping of the environment at risk;
- Identified priorities for response (with input from potentially affected or concerned parties);
- Shoreline cleanup strategies;
- Handling instructions for spilled oil, chemicals, fuels or other recovered contaminated materials, including their transportation, temporarily storage, and disposal.

F. Surface Storage or Disposal Pits

If surface pits or ponds are used for wastewater storage or for interim disposal during operations, the pits should be constructed outside environmentally sensitive locations.

- Installation of a liner so that the bottom and sides of the pit have a coefficient of permeability no greater than 1 x 10-7 centimeters per second (cm/sec). Liners should be compatible with the material to be contained and of sufficient strength and thickness to maintain the integrity of the pit. Typical liners may include synthetic materials, cement/clay type or natural clays, although the hydraulic conductivity of natural liners should be tested to ensure integrity
- Construction to a depth of typically 5 m above the seasonal high water table
- Installation of measures (e.g., careful siting, berms) to prevent natural surface drainage from entering the pit or breaching during heavy storms
- Installation of a perimeter fence around the pit or installation of a screen to prevent access by people, livestock and wildlife (including birds)
- Regular removal and recovery of free hydrocarbons from the pit contents surface
- Removal of pit contents upon completion of operations and disposal in accordance with the waste management plan
- Reinstatement of the pit area following completion of operations

Workover and completion wastes

Workover and completion wastes result from operations where an oil well's head is partially open to the atmosphere and is filled with a water base fluid that maintains pressure on the formation to prevent blowout. Workover fluid is injected into such a well while the well's interior tubing string, valves, packer gaskets, or other components are undergoing maintenance. When maintenance is complete, the workover fluid is removed from the well before starting routine operation. Completion fluids are typically used in a well when the well casing is perforated just before starting production. Both fluids become contaminated with oil and formation brine.

Proppants/frac sand

Proppants (also called "frac sand") refers to the aluminum silicate beads of varying sizes injected into wells to hold formation fractures open, thus increasing subsurface oil flow to the wells. When these materials are transported back to facilities with crude oil from the wells, the beads settle out, along with formation sand, to form a semi-solid sludge in the bottoms of vessels.

Bottom wastes

Tank bottom wastes are a type of sediment that accumulates in oil field vessels and pipelines when fluid turbulence is low. These dense sludges are composed of crude oil, paraffin, asphaltics, reservoir material, drilling mud, and slightly radioactive material (called NORM) in addition to the frac sand/proppant discussed above.

Dehydration and sweetening wastes

Polyols and glycols are used in the oil and gas industry as antifreeze additives and to remove traces of water from natural gas streams in the production of fuel gas. Waste dehydration polyols and glycols sometimes emit traces of benzene.

H_2S, a corrosive gas more toxic than hydrogen cyanide, is emitted by sulfate-reducing bacteria growing in subsurface formations and oil field surface equipment.

Oily debris and filter media

Oily debris saturated with crude oil comes from oil spill cleanups (minor and major) and can include oily soil and gravel. Similarly, filter media which filter crude oil may become saturated with oil.

Hydrocarbon wastes

Oil fields generate waste hydrocarbons such as "dirty diesel" fuel contaminated from pressure testing pipelines.

Table 3-3: Potential Material Outputs from Selected Oil and Gas Extraction Processes

Process	Air Emissions	Process Waste Water	Residual Wastes Generated
Well development	fugitive natural gas, other volatile organic	drilling muds, organic acids, alkalis, diesel oil,	drill cuttings (some oil-coated), drilling mud

Process	Air Emissions	Process Waste Water	Residual Wastes Generated
	compounds (VOCs), Polyaromatic hydrocarbons (PAHs), carbon dioxide, carbon monoxide, hydrogen sulfide	crankcase oils, acidic stimulation fluids (hydrochloric and hydrofluoric acids)	solids, weighting agents, dispersants, corrosion inhibitors, surfactants, flocculating agents, concrete, casing, paraffins
Production	Fugitive natural gas, other VOCs, PAHs, carbon dioxide, carbon monoxide, hydrogen sulfide, fugitive BTEX (benzene, toluene, ethylbenzene, and xylene) from natural gas conditioning	produced water possibly containing heavy metals, radionuclides, dissolved solids, oxygen-demanding organic compounds, and high levels of salts. also may contain additives including biocides, lubricants, corrosion inhibitors. wastewater containing glycol, amines, salts, and untreatable emulsions	produced sand, elemental sulfur, spent catalysts, separator sludge, tank bottoms, used filters, sanitary wastes
Maintenance	volatile cleaning agents, paints, other VOCs, hydrochloric acid gas	completion fluid, wastewater containing well-cleaning solvents (detergents and degreasers), paint, stimulation agents	pipe scale, waste paints, paraffins, cement, sand
Abandoned Wells, Spills and Blowouts	fugitive natural gas and other VOCs, PAHs, particulate matter, sulfur compounds, carbon dioxide, carbon monoxide	escaping oil and brine	contaminated soils, sorbents
Sources: Siting, 1978, EPA Office of Solid Waste, 1987			

G. Decommissioning

Decommissioning of onshore facilities usually includes the complete removal of permanent facilities and well abandonment, including associated equipment, material, and waste disposal or recycling. General guidance on the prevention and control of common environmental impacts during decommissioning activities is provided in the General EHS Guidelines. Specific additional requirements to consider for oil and gas facilities include well abandonment and pipeline decommissioning options.

Wells should be abandoned in a stable and safe condition. The hole should be sealed to the ground surface with cement plugs and any known hydrocarbon zones should be isolated to prevent fluid migration. Aquifers should also be isolated. If the land is used for agriculture, the surface casing should be cut and capped below plow depth.

Decommissioning options for pipelines include leaving them in place, or removing them for reuse, recycling or disposal, especially if they are above ground and interfere with human activities. Pipelines left in place should be disconnected and isolated from all

potential sources of hydrocarbons; cleaned and purged of hydrocarbons; and sealed at its ends.

A preliminary decommissioning and restoration plan should be developed that identifies disposal options for all equipment and materials, including products used and wastes generated on site. The plan should consider the removal of oil from flow lines, the removal of surface equipment and facilities, well abandonment, pipeline decommissioning and reinstatement. The plan should be further developed during field operations and fully defined in advance of the end of field life, and should include details on the provisions for the implementation of decommissioning activities and arrangements for post-decommissioning monitoring and aftercare.

3.3 Risk Potential in Bulk Storage and Handling of Hazardous Chemicals for Oil/Gas Drilling

There are various hazardous bulk chemicals (toxic and flammable), which will be used during exploratory and production drilling. Storage areas are provided for these fuels and these should be handled with utmost care following the safety norms for handling of hazardous chemicals. Bulk storages are required for those fuels, which will be required in the large quantity and are flammable/toxic in nature. The storage tanks should be in an isolated zone and should have firewater hydrant system.

Storing bentonite, mixing areas and supply lines

As using bentonite is required for drilling, ensure that it is contained well within the working area and does not enter any watercourses or surface water drains. Ensure that storage silos are bunded. Surround areas where bentonite is mixed with a small wall or contain them within a bund. This will help to control the slurry produced and prevent it from entering surface water drains or watercourses. Position bentonite storage silos and supply lines as far as possible from surface water drains or watercourses.

Heavy Fuel Oils having flash points above 55°C is not classified as flammable. Flammability limits for fuel vapour /air mixtures lie between approximately 1.0 to 6.0 % (V/V); auto-ignition temperatures are in the range of approximately 220 to 300°C. Ignition of heavy fuel oils at ambient temperature may be difficult, but if ignited at elevated temperatures, the product will burn, it is recommended that the head space of all heavy fuel oil tanks should be considered potentially flammable and appropriate precautions taken.

3.3.1 Hazard identification

Identification of hazards in QRA is of primary significance in the analysis, quantification and cost-effective control of accidents involving chemicals and process. A classical definition of hazard states that hazard is in fact the characteristic of system/plant/process that presents potential for an accident. Hence, all the components of a system/plant/ process need to be thoroughly examined to assess their potential for initiating or propagating an unplanned event/sequence of events, which can be termed as an accident. The typical methods for hazard identification employed are:

- Identification of major hazardous units based on Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 of Government of India (as amended in 2000); and

- Identification of hazardous units and segments of plants and storage units based on relative ranking technique, viz. Fire-Explosion and Toxicity Index (FE&TI).

Hazardous substances may be classified into three main classes namely Flammable substances, unstable substances and Toxic substances. Flammable substances require interaction with air for their hazard to be realized. Under certain circumstances the vapours arising from flammable substances when mixed with air may be explosive, especially in confined spaces. However, if present in sufficient quantity such clouds may explode in open air also. Unstable substances are liquids or solids, which may decompose with such violence so as to give rise to blast waves. Besides, toxic substances are dangerous and cause substantial damage to life when released into the atmosphere. The ratings for a large number of chemicals based on flammability, reactivity and toxicity have been given in NFPA Codes 49 and 345 M.

Table 3-4: Applicability of GOI Rules To Fuel/Chemical Storage

S. No.	Chemical/ Fuel	Listed in Schedule	Threshold Quantity (T) for Application of Rules	
			5,7-9, 13-15	10-12
1	Light Diesel Oil	1 (part I)	5000 MT	50000 MT
2	Heavy Fuel Oil	1(part I)	5000 MT	50000 MT
3	Chlorine	3 (part I)	10 MT	25 MT
4	HSD	1 (part I)	5000 MT	50000 MT
5	Natural gas	3 (part I)	--	--

A systematic analysis of the fuels/chemicals and their quantities of storage is required, to determine threshold quantities as notified by GOI Rules, 1989 (as amended in 2000) and the applicable rules are as above.

Table 3-5: Properties of Fuels/Chemicals Used In Drilling

Chemical	Codes/Label	TLV	FBP	MP	FP	UEL	LEL
			°C			%	
Light Diesel Oil	Flammable	--	360	-	66	-	-
Heavy Fuel Oil	Flammable	--	400	338	65	7.5	0.6
Chlorine	Toxic	1 ppm	34	-	-101	-	-
HSD	Flammable	--	375	-	70	-	-
Natural Gas	Flammable	--	--	--	--	-	-

Note:

TLV: Threshold Limit Value
MP: Melting Point
UEL: Upper Explosive Limit
FBP: Final Boiling Point
FP: Flash Point
LEL: Lower Explosive Limit

Fire explosion and toxicity index (Fe&Ti) approach

FE&Ti is a rapid ranking method for identifying the degree of hazard. The application of FE&Ti helps in making a quick assessment of the nature and quantification of the hazard in these areas. However, this does not provide precise information. Respective Material Factor (RMF), General Hazard Factors (GHF), Special Process Hazard Factors (SPHF) are computed using standard procedure of awarding penalties based on storage handling and reaction parameters. Before hazard indexing can be applied, the installation in question should be subdivided into logical, independent elements or units. In general, a unit can logically be characterized by the nature of the process that takes place in it. In some cases, the unit may consist of a plant element separated from the other elements by space or by protective walls. A plant element may also be an apparatus, instrument, section or system that can cause a specific hazard. For each separate plant process which contains flammable or toxic substances, a fire and explosion index (F) and/or a toxicity index (T) could be determined in a manner derived from the method for determining a fire and explosion index developed by the DOW Chemical Company.

DOW's Fire and Explosion Index (F and E) is a product of Material Factor (MF) and hazard factor (F3) while MF represents the flammability and reactivity of the substances, the hazard factor (F3), is itself a product of General Process Hazards (GPH) and special process hazards (SPH). An accurate plot plan of the plant, a process flow sheet and F&E Index and Hazard Classification Guide published by DOW are required to estimate the FE&Ti of any process plant or a storage unit. The F&E index can be calculated from the following formula:

F&EI = MF x (GPH) x (SPH)

The degree of hazard potential is identified based on the numerical value of F&EI as per the criteria given below:

F&EI Range	Degree of Hazard
0-60	Light
61-96	Moderate
97-127	Intermediate
128-158	Heavy
159-up	Severe

The toxicity index is primarily based on the index figures for health hazards established by the NFPA in codes NFPA 704, NFPA 49 and NFPA 345 m. By comparing the indices F&EI and TI, the unit under QRA is classified into one of the following three categories established for the purpose.

Table 3-6: F&EI and TI Categories

Category	Fire and Explosion Index (F&EI)	Toxicity Index (TI)
I	F&EI < 65	TI < 6
II	65 < or = F&EI < 95	6 < or = TI < 10
III	F&EI > or = 95	TI > or = 10

Certain basic minimum preventive and protective measures are required for the three hazard categories. Fire and Explosion are also the likely hazards due to the fuel storage hence, FE&TI should be estimated.

3.3.2 Hazard assessment and evaluation

A preliminary hazard analysis is carried out to identify the major hazards associated with storages in the plant. This is followed by consequence analysis to quantify these hazards. Finally the vulnerable zones are plotted for which risk reducing measures are deduced and implemented.

Physical and Health Occupational Hazards in any large scale Chemical /Hydrocarbon Processing Industry (CPI/HPI) can be broadly classified into the following categories:

- Mechanical Risks
- Electrical Risks
- Fire/Explosion Risks
- High /low Temperature Exposure Risks
- Toxic/Carcinogenic Chemicals Exposure Risks
- Corrosive/Reactive/Radioactive Chemicals Exposure Risks

The first two types of risks are of universal nature associated with any industrial activity and not specific to a particular plant or process. Mechanical risks which are generally encountered are injuries to the head, Limbs, eyes, *etc.,* usually as a result of negligence on the part of operating/maintenance personnel in the use of improper tools, by-passing prescribed safety procedures neglect of personal protective wear and risks associated with rotating machinery as well as risks associated with high-energy release from compressed gases. Electrical risks which result in shock and/or burns are most often a consequence of poor maintenance, ingress of dust or moisture, handling by unauthorized personnel and use of improper/substandard hardware.

3.3.3 Failure mode analysis

There are various modes in which flammable and toxic chemicals can leak into atmosphere causing adverse affects. It may be small leaks from gaskets of the flanged joints, or guillotine failure of a pipeline of even catastrophic failure of the storage tank. Some typical modes of failures and their possible causes are discussed below:

Table 3-7: Failure Mode Analysis

S.No.	Failure Mode	Probable Cause	Remarks
1.	Flange / Gasket failure	Incorrect gasket Incorrect installation.	Attention to be paid during selection and installation of gaskets.
2	Weld failure	It is normally due to poor quality of welds	Welding to be done by certified welders with right quality of welding rods. Inspection and radiography must also be done.

S.No.	Failure Mode	Probable Cause	Remarks
3	Pipe corrosion erosion or failure due to stress	Some times fabrication or installation leaves stress in the pipes. Erosion or corrosion also is sometimes the cause.	Pipes material of construction should be selected correctly. Design should take care of erosion effects. And installation of pipes should not leave any stress.
4	Over pressurization of pipeline	Over pressurization can occur due to failure of SRV or incorrect operation.	Necessary procedures should be there to prevent.
5	Deficient installation of pipes	Pipes design and installation is sometimes not as per appropriate standard.	It must be ensured that installation is as per correct standards completely.
6	Leaks from valve	Leaks from glands, bonnets or failures valves spindle is sometimes the cause.	Right selection of valves and their maintenance should be ensured.
7	Instruments failure	Multifarious instruments are used for control of process parameters. Any such instrument failure can cause mishap.	Reliability of instruments working must be ensured through proper selection and maintenance.
8	Failures of protective system	Protective system like SRV, bursting discs, vent header, drain lines *etc*., are provided to take care of abnormal conditions.	Reliability of protective system must be ensured highest through inspection and proper maintenance.
9	Operational effort	Plant operational parameters should not be exceeded beyond the permissible limits.	Operating procedures must be complete and strictly followed.
10	Other failures	There are external other reasons causing the failures.	Design and operating philosophy must consider all possible reasons.

3.3.4 Preliminary hazard analysis (PHA)

The purpose of the preliminary hazards analysis is to identify early in the design process the potential hazards associated with, or inherent in the design, thus eliminating costly and time consuming delays caused by design changes made later. This also eliminates potential hazard points at design stage itself.

An assessment of the conceptual design is conducted for the purpose of identifying and examining hazards related to stored materials, utility and support systems, environmental factors, proposed drilling operations, facilities, and safeguards.

In the proposed installation major hazard is fire due to the storage of fuel/chemicals. Other hazardous installation is the borehole where the oil/gas coming out could get ignited at various stages of operation.

3.3.4.1 Electrical hazards

Electrical hazards leading to fire and explosion in switchgear and other equipment mainly due to failure of circuit breakers, insulators, fuses, busbars, and poor maintenance. Accidents may also occur in transformer due to open arcing, flashover above oil level, insulator failure, overloading, failure of air cooling system, lighting *etc*., Nevertheless, all these hazards lead to localized accidents only.

3.3.4.2 Fire hazards

There could be other areas in the installation that have a potential for fire hazard and require adequate fire fighting equipment. These are considered here since uncontrolled fire may trigger the above emergencies due to domino effect. However for the proposed installation, safety guidelines will be as per Tariff Advisory Committee.

3.3.4.3 Cable galleries (DG Room)

For containment of fire and preventing it from spreading in the cable galleries, unit wise fire barriers with self-closing fire resistant doors are planned. The ventilation system provided in the cable galleries will be interlocked with the fire alarm system so that, in the event of a fire alarm, the ventilation system is automatically switched off. Also to avoid spreading of fire, all cable entries/openings in cable galleries, tunnels, channels, floors, barriers *etc*., will be sealed with non-inflammable/fire resistant sealing material.

3.3.4.4 Toxic release

In some instances use of chorine may be required, which is toxic. If not handled properly it will lead to toxicity. Self-contained breathing apparatus will be available at the installation in the event of leakage in case of emergency. Workers will be trained in handling the self-contained breathing apparatus. Since the quantity of toxic release will be limited, off site implications of release are not envisaged.

Table 3-8: Preliminary Hazard Analysis for Process/Storage Areas

Equipment	Process/Storage	Potential Hazard	Provision
Turbine	Converts pressure in the fuel into mechanical energy.	Mechanical and fire hazards.	Layout of equipment/ machinery is done in accordance with plant and electrical inspectorate.
Generator	Converts mechanical energy into electrical energy.	Mechanical hazards and fire hazards in Lube oil system Cable galleries Short circuits	As above
Power Transformers	-	Fire and explosion	All electrical fittings and cables are provided as per the specified standards. Ensure that all electrical cabling in the area are properly insulated

Equipment	Process/Storage	Potential Hazard	Provision
			and covered. Foam / CO_2 / dry powder type fire extinguishers are to be provided.
Switch Yard	Switch Yard	Fire	As above
Switch Yard control room	-	Fire in cable galleries and switch	As above
DG set		Fires in Cable galleries, Short circuits in Control Rooms and Switch-gears	Layout of equipment and machinery according to Plant & electrical inspectorate
Natural Gas pipeline		Fire and Explosion	Frequent monitoring of valves and joints. Sprinkling system shall be provided. Ensure that all electrical cabling in the area are properly insulated and covered. Foam / CO_2 / dry powder type fire extinguishers are to be provided. Pipeline design as per OISD norms.
Chlorine	Used for water treatment in different phases in cooling water, potable water and raw water.	Toxic accidental release	Leak detection and neutralization system will be provided.
HFO storage (Heavy Fuel)		Combustion at elevated temperature	Leak detection and neutralization system will be provided.
LDO Storage		Fire	
HSD		Fire	

Table 3-9: Preliminary Hazard Analysis for the Installation in General

PHA Category	Description of Plausible Hazard	Provision
Environmental factors	If there is any leakage and eventuality of source of ignition.	All electrical fittings and cables are provided as per the specified standards. All motor starters are flame proof.
	Highly inflammable nature of the fuel/chemicals may cause fire hazard	A well designed fire protection including protein foam, dry powder, CO_2 extinguisher should be provided. Fire extinguisher of small size and big size are provided at all potential fire hazard places.

3.3.5 Safety measures

3.3.5.1 Maximum credible accident (MCA) analysis

Hazardous substances may be released as a result of failures or catastrophes, causing possible damage to the surrounding area. This section deals with the question of how the consequences of the release of such substances and the damage to the surrounding area can be determined. MCA analysis encompasses certain techniques to identify the hazards and calculate the consequent effects in terms of damage distances of heat radiation, toxic releases, vapour cloud explosion, *etc*. A host of probable or potential accidents of the major units in the complex arising due to use, storage and handling of the hazardous materials are examined to establish their credibility. Depending upon the effective hazardous attributes and their impact on the event, the maximum effect on the surrounding environment and the respective damage caused can be assessed.

Consequence analysis is basically a study of quantitative analysis of hazards due to various failure scenarios. It is that part of risk analysis, which considers failure cases and the damage caused by these failure cases. It is done in order to form an opinion on potentially serious hazardous outcome of accidents and their possible consequences. The reason and purpose of consequence analysis are many folds like:

- Part of Risk Assessment
- Plant Layout/Code Requirements
- Protection of surroundings
- Protection of the public
- Emergency Planning
- Design Criteria

The results of consequence analysis are useful for getting information about all known and unknown effects that are of importance when some failure scenario occurs in the plant and also to get information as how to deal with the possible catastrophic events. It also gives the workers at the installation and people the vicinity, an understanding of their personal situation.

3.3.6 Damage criteria

The storage and unloading at the storage facility may lead to fire and explosion hazards. The damage criteria due to an accidental release of any hydrocarbon arise from fire and explosion.

Tank fire would occur if the radiation intensity is high on the peripheral surface of the tank leading to increase in internal tank pressure. Fire would occur when the flammable liquid/gas due to leakage gets ignited.

3.3.6.1 Fire damage

A flammable liquid in a pool will burn with a large turbulent diffusion flame. This releases heat based on the heat of combustion and the burning rate of the liquid/gas. A part of the heat is radiated while the rest is converted away by rising hot air and

combustion products. The radiations can heat the contents of a nearby storage unit to above its ignition temperature and thus result in a spread of fire.

The radiations can also cause severe burns or fatalities of workers or fire fighters located within a certain distance. Hence, it will be important to know beforehand the damage potential of a flammable pool likely to be created due to leakage or catastrophic failure of a storage vessel. This will help to decide the location of other storage/vessels, decide the type of protective clothing the workers/fire fighters need, the duration of time for which they can be in the zone, the fire extinguishing measures needed and the protection methods needed for the nearby storage vessels.

Table 3-11 tabulates the damage effect on equipment and people due to thermal radiation intensity whereas; the effect of incident radiation intensity and exposure time on lethality is given in Table 3-11.

Table 3-10: Damage Due to Incident Radiation Intensities

Sr. No.	Incident Radiation (kW/m^2)	Type of Damage Intensity	
		Damage to Equipment	Damage to People
1	37.5	Damage to process equipment	100% lethality in 1 min. 1% lethality in 10 sec.
2	25.0	Minimum energy required to ignite wood at indefinitely long exposure without a flame	50% Lethality in 1 min. Significant injury in 10 sec.
3	19.0	Maximum thermal radiation intensity allowed on thermally unprotected adjoining equipment	--
4	12.5	Minimum energy to ignite with a flame; melts plastic tubing	1% lethality in 1 min.
5	4.5	--	Causes pain if duration is longer than 20 sec, however blistering is un-likely (First degree burns)
6	1.6	--	Causes no discomfort on long exposures
Source: Techniques for Assessing Industrial Hazards by World Bank.			

Table 3-11: Radiation Exposure and Lethality

Radiation Intensity (kW/m^2)	Exposure Time (seconds)	Lethality (%)	Degree of Burns
1.6	--	0	No Discomfort even after long exposure
4.5	20	0	1 st
4.5	50	0	1 st
8.0	20	0	1 st
8.0	50	<1	3 rd

Radiation Intensity (kW/m^2)	Exposure Time (seconds)	Lethality (%)	Degree of Burns
8.0	60	<1	3 rd
12.0	20	<1	2 nd
12.0	50	8	3 rd
12.5	--	1	--
25.0	--	50	--
37.5	--	100	--

3.3.6.2 Damage due to explosion

Explosion is a sudden and violent release of energy accompanied by the generation of pressure wave and a loud noise. The rate of energy release is very large and has potential to cause serious injury to the people, damage the nearby property *etc*. The effect of over-pressure can directly result in deaths to those working in the immediate vicinity of the explosion. The pressure wave may be caused by a BLEVE (Boiling Liquid Expanding Vapour Cloud) or Vapour Cloud explosion.

3.3.6.3 BLEVE - fireball

BLEVE is sometimes referred to as a fireball. A BLEVE is a combination of fire and explosion with an intense radiant heat emission within a relatively short time interval. This phenomenon can occur as a result of overheating of a pressurized vessel by a primary fire. If a pressure vessel fails as a result of a weakening of its structure the contents are instantaneously released from the vessel as a turbulent mixture of liquid and gas expanding rapidly and dispersing in air as a cloud. When this cloud is ignited a fireball occurs causing enormous heat radiation intensity within a few seconds. This heat intensity is sufficient to cause severe skin burns and deaths at several hundred meters from the vessel, depending on the quantity of gas involved. A BLEVE can therefore be caused by a physical impact on a vessel or a tank, which is already overstressed.

3.3.6.4 Vapour cloud explosion

Explosion can be confined and unconfined vapour cloud explosions. Confined explosions are those, which occur within some sort of containment such as a vessel or pipeline. Explosions which occur in the open air are referred to as unconfined explosions and produce peak pressures of only a few kPa. The peak pressures of confined explosions are generally higher and may reach hundreds of kPa. Table 3-13 tabulates the damage criteria as a result of peak over pressure of a pressure wave on structures and people.

Table 3-12: Damage Due to Peak over Pressure

Human Injury		Structural Damage	
Peak Over Pressure (bar)	Type of Damage	Peak Over Pressure (bar)	Type of Damage
5 - 8	100% lethality	0.3	Heavy (90% damage)

Human Injury		Structural Damage	
Peak Over Pressure (bar)	**Type of Damage**	**Peak Over Pressure (bar)**	**Type of Damage**
3.5 - 5	50% lethality	0.1	Repairable (10% damage)
2 - 3	Threshold lethality	0.03	Damage of Glass
1.33 - 2	Severe lung damage	0.01	Crack of Windows
1 - $1^{1/3}$	50% Eardrum rupture	-	-
Source: Marshall, V.C. (1977) ' How lethal are explosives and toxic escapes'.			

3.3.6.5 Effect due to toxic gas release

Chlorine is a greenish-yellow, highly reactive halogen gas that has a pungent, suffocating odor. The vapor is heavier than air and will form a cloud in the vicinity of a spill. Like other halogens, chlorine exists in the diatomic state in nature. Chlorine is extremely reactive and rapidly combines with both inorganic and organic substances. Chlorine is an eye and respiratory tract irritant and, at high doses, has direct toxic effects on the lungs

The critical values of chlorine concentrations in air are given in Table 3-14.

Table 3-13: Critical Concentrations for Chlorine

Criteria	Concentration
90% lethality (10 min exposure)	866 ppm
50% lethality (10 min exposure)	433 ppm
10% lethality (10 min exposure)	217 ppm
Immediate Damage to life and Health (IDLH)	25 ppm

3.3.6.6 Typical scenarios considered in oil/gas drilling for MCA analysis

Based on the storage and properties of the chemicals at the site, some typical scenarios relevant for MCA analysis include:

Table 3-14: Scenarios Considered For MCA Analysis

Sr. No.	Fuel/Chemical	Quantity	Pool Fire	Explosion	Toxic Release	Jet Fire
1	Failure of LDO storage tanks		*	-	-	--
2	Catastrophic Failure of LDO + HFO Storage Tanks		*	-	-	--
3	Failure of Chorine cylinder		-	-	*	--

Sr. No.	Fuel/Chemical	Quantity	Pool Fire	Explosion	Toxic Release	Jet Fire
4	Catastrophic Failure of all HSD Storage Tanks		*	-	-	--
5	Catastrophic Failure of Natural Gas Pipeline connected to turbine		-	-	-	*

Note:

** Considered for MCA Analysis*
 # Most likely scenario is leakage of Chlorine and forming toxic cloud during unloading operation and leakage of Hydrogen leading to explosion during filling operation.

A perusal of the above table indicates that major material storage is flammable liquid. Fires could occur due to presence of ignition source at or near the source of leak or could occur due to flashback upon ignition of the traveling vapor cloud. Tank fires may occur due to the following:

- Ignition if rim seal leak leading to rim seal fire and escalating to full-fledged tank fire. Lighting is a major source of ignition of tank fires; and
- Overflow from tank leading to spillage and its subsequent ignition, which flashes back to the tank leading to tank fire. The chance of overflow should be less unless operator has grossly erred. Spillage due to overflow may result in a dyke fire if ignition occurs after sufficiently long period.
- For radiation calculations, pool fire may be important and the criteria of 4.5 kW/m^2 could be selected to judge acceptability of the scenarios. The assumptions for calculations are:
- It is not continuous exposure;
- It is assumed that No fire detection and mitigation measures are initiated;
- There is not enough time available for warning the public and initiating emergency action;
- Secondary fire at public road and building is not likely to happen;
- The effect of smoke on reduction of source radiation intensity has not been considered; therefore hazard distances calculated tend to be conservative; and
- Shielding effect of intervening trees or other structures has not been considered. No lethality is expected from this level of intensity although burn injury takes place depending on time of exposure.

3.3.7 Consequence analysis

3.3.7.1 Effect of thermal radiation on population

TLV of 1.6 kW/m^2 can be adopted as the safe radiation intensity for human population even for long exposures to calculate safe zone.

Domino effect

The term domino effect denotes a chain of accidents, or situations, in which a fire/explosion load generated by an accident in one area causes secondary and higher order accidents in other areas. Such chains of accidents have a greater propensity to cause damage than stand-alone accidents.

3.4 Summary of Applicable National Regulations

3.4.1 General description of major statutes

A comprehensive list of all the laws, rules, regulations, decrees and other legal instruments applicable to oil & gas exploration industry is annexed as **Annexure I**.

3.4.2 Industry specific requirements

3.4.2.1 Standards for liquid effluent

A. Onshore facilities

Table 3-15: Standards for Marine Disposal

	Parameters	Concentration not to exceed
Onshore Facilities (for marine disposal)	pH	5.5-9.0
	Oil & grease	10 mg/l
	Suspended solids	100 mg/l
	BOD, 27°C for 3 days	30 mg/l

For on-shore discharge of effluents, in addition to the standards prescribed above, proper marine outfall has to be provided to achieve the individual pollutant concentration level in sea water below their toxicity limits as given below, within a distance of 50 metre from the discharge point, in order to protect the marine aquatic life.

Table 3-16: Toxicity Limits

Parameter	Toxicity limit, mg/l
Chromium, as Cr	0.1
Copper, as Cu	0.05
Cyanide, as CN	0.005
Fluoride, as F	1.5
Lead, as Pb	0.05
Mercury, as Hg	0.01
Nickel, as Ni	0.1
Zinc, as Zn	0.1

Oil and gas drilling and processing facilities, situated on land and away from saline water sink, may opt either for disposal of treated water by onshore disposal or by re-injection in abandoned well, which is allowed only below a depth of 1000m from the ground level . In case of re-injection in abandoned well the effluent have to comply only w.r.t. suspended solids and oil & grease at 100 mg/l and 10 mg/l, respectively. For onshore disposal, the permissible limits are given below:

Table 3-17: Onshore Discharge Standards

S.No	Parameter	On-shore discharge standards (Not to exceed)
1	pH	5.5 -9.0
2	Temperature	40°C
3	Suspended solids	100 mg/l
4	Zinc	2 mg/l
5	BOD at 27°Cfor 3 days	30 mg/l
6	COD	100mg/l
7	Chlorides	600 mg/l
8	Sulphates	1000 mg/l
9	Total Dissolved Solids	2100 mg/
10	% Sodium	60 mg/l
11	Oil & grease	10 mg/l
12	Phenolics	1.2 mg/l
13	Cyanides	0.2 mg/l
14	Fluorides	1.5 mg/l
15	Sulphides	2.0 mg/l
16	Chromium (hexavalent)	0.1 mg/l
17	Chromium (Total)	1.0 mg/l
18	Copper	0.2 mg/l
19	Lead	0.1 mg/l
20	Mercury	0.01 mg/l
21	Nickel	3.0 mg/l

B. Offshore facilities

For offshore discharge of effluents, the oil content of the treated effluent without dilution shall not exceed 40 mg/l for 95% of the observation and shall never exceed 100 mg/l. Three 8hourly grab samples are required to be collected daily and the average value of soil and grease content of the three samples should comply with these standards.

3.4.2.2 Guidelines for discharge of gaseous emissions

DG sets

DG sets at drill site as well as production station should conform with the norms notified under the Environment (Protection) Act, 1986.

Elevated / ground flares

- Cold venting of gases should never be resorted to under any circumstances and all gaseous emissions are to be flared.
- All faring shall be done by elevated flares except where there is any effect on crop production in adjoining areas due to glaring. In such cases, one should adopt ground flaring with scientifically designed burners to reduce luminosity, heat, smoke, *etc*., and also construct obstruction to make the flame obscure.
- In case of elevated flaring the minimum stack height shall be 30 m. the flare tip should be scientifically designed with steam/air injection *etc*., to reduce smoke.
- For flaring sour gas the minimum stack height should be decided as below:
  - (a) Calculate stack height by using the formula H = 14 Q 0.3
  - Where, H is the height of stack in m and Q is the kg/ hr of SO_2 emitted.
  - (b) Using the above H calculate the maximum GLC ofSO2 which should not exceed the CPCB limits.
  - (c) In case the maximum GLC exceeds, stack height is to be increased so as to bring the GLC below the limits. However the minimum stack height shall not be less than 30 m.
- The maximum GLC caused by emission from various stacks shall be worked out and in no case the maximum resultant GLC should exceed the CPCB limits.
- At the drill sites where oil-based muds are used, oil vapours should be channelized and connected to elevated flares of minimum 30 m height

Ground flares

Ground flaring of all gases at surface flares pits to be adopted only as a last resort. Following procedure is to be adopted to minimize effects of surface pit flaring.

- The flare pit at GGS/ OCS and GCS should be made of RCC surrounded by a permanent wall (made of refractory brick) of 5m height minimum, to reduce the radiation and glaring effects in adjoining areas.
- Gas distribution system and planning of operation should be such that flaring is minimal.
- Enclosed ground flare system should be used.

General

Ambient Air Quality around the drill site should be monitored at least once a week for 3 months. In case the readings of various pollutants measured exceed the limits, the frequency of monitoring shall be reviewed and further investigations should be carried out to find out the reasons and initiate mitigative measures.

The drilling exploration production industry must submit detail report to the government the efforts already made and planned for the development of infrastructure and

prospective customers for maximizing utilization of associated gas within a time frame which may be fixed by Ministry of environment & forests (Government of India) and ? or central or state Pollution Control Board.

3.4.2.3 Guideline for disposal of solid wastes

Disposal of Drill cuttings & Drilling Fluids for Onshore installations

- Drill cuttings (DC) originating from on-shore or locations close to shore line and separated from water Base MUD (WBM) should be properly washed and unusable drilling fluids (DF) such as WBM, Oil Base MUD (OBM), Synthetic Base Mud (SBM)) should be disposed off in a well designed pit lined with impervious liner located off-site or on-site. The disposal pit should be provided additionally with leachate collection system.
- Design aspects of the impervious waste disposal pit, capping of disposal pit should be informed by the oil industry to SPCB at the time of obtaining consent.
- Use of diesel base mud is prohibited. Only WBM should be used for on-shore oil drilling operations.
- In case of any problem due to geological formation for drilling, low toxicity OBM having aromatic content < 1% should be used. If the operators intend to use such OBM to mitigate specific hole problem/SBM it should be intimated to MoEF/ SPCB.
- The chemical additives used for the preparation of DF should have low toxicity *i.e*. 96 hr LC50 > 30,000 mg/l as per mysid toxicity test conducted on locally available sensitive sea species. The chemicals used (mainly organic constituents) should be biodegradable.
- DC separated from OBM after washing should have oil content at < 1% should be used. If the operators intend to use such OBM to mitigate specific hole problem/ SBM it should be intimated to MoEF/SPCB.
- The waste pit after it is filled up shall be covered with impervious liner, over which, a thick layer of native soil with proper top slope be provided
- Low toxicity OBM should be made available at installation during drilling operation.
- Drilling wastewater including DC wash water should be collected in the disposal pit, evaporated or treated and should comply with the notified standards for onshore disposal.
- Barite used in preparation of DF shall not contain Hg> 1 mg/kg & Cd > 3 mg/kg.
- Total material acquired for preparation of drill site must be restored after completion of drilling operation leaving no waste material at site. SPCB should be informed about the restoration work.

In case, environmentally acceptable methods for disposal of drill waste such as:

- injection to a formation through casing annulus, if conditions allow,
- land farming at suitable location
- bio-remediation
- incineration or
- solidification can be considered, in that case oil industry is required to submit proposal to SPCB/ MoEF for approval

4. OPERATIONAL ASPECTS OF EIA

Prior environmental clearance process has been revised in the Notification issued on 14th September, 2006 into following four major stages *i.e.* screening, scoping, public consultation and appraisal. Each stage has certain procedures to be followed. This section deals with all the procedural and technical guidance for conducting making the objective oriented EIA report, its review and decision making. Besides, the Notification classified projects into Category A, which requires prior environmental clearance from MoEF and Category B from SEIAA/UTEIAA.

Consistency with Other Requirements

- Clearance from other regulatory bodies is not a pre-requisite for obtaining the prior environmental clearance and all such clearances will be treated as parallel statutory requirements.
- Consent for Establishment (CFE) and Prior Environmental Clearance are two different legal requirements, a project proponent is required to be taken. Therefore, these two activities can be initiated and proceeded with simultaneously.
- If a project is covered by the provisions of CRZ and EIA Notifications, then the project proponent is required to take separate clearances from the concerned authorities.
- Rehabilitation and Resettlement issues need not be dealt under the EIA Notification as other statutory bodies deal with these issues. However, socio-economic studies be considered while taking environmental decision

4.1 Coverage of Offshore and Onshore Oil and Gas Exploration, Development & Production Industry under the Purview of Notification

All the new offshore and onshore oil and gas exploration, development & production industrial projects including expansion and modernization require prior environmental clearance from Central Government. Based on pollution potential, these projects are classified in to Category A.

Note: Exploration surveys (not involving drilling) are exempted from the Notification provided the concession areas have got previous clearance for physical surveys.

In case of Expansion or Modernization of the developmental Activity:

- Any developmental activity, which was issued EIA clearance (existing plant), when undergoes expansion or modernization (change in process or technology) with increase in production capacity or any change in product mix beyond the list of products cleared in the issued clearance is required to submit new application for EIA clearance.
- Any developmental activity, which is listed in Schedule of the EIA Notification and after expansion due to its total capacity, if falls under the purview of Category A, then such developmental activities requires clearance from MoEF.

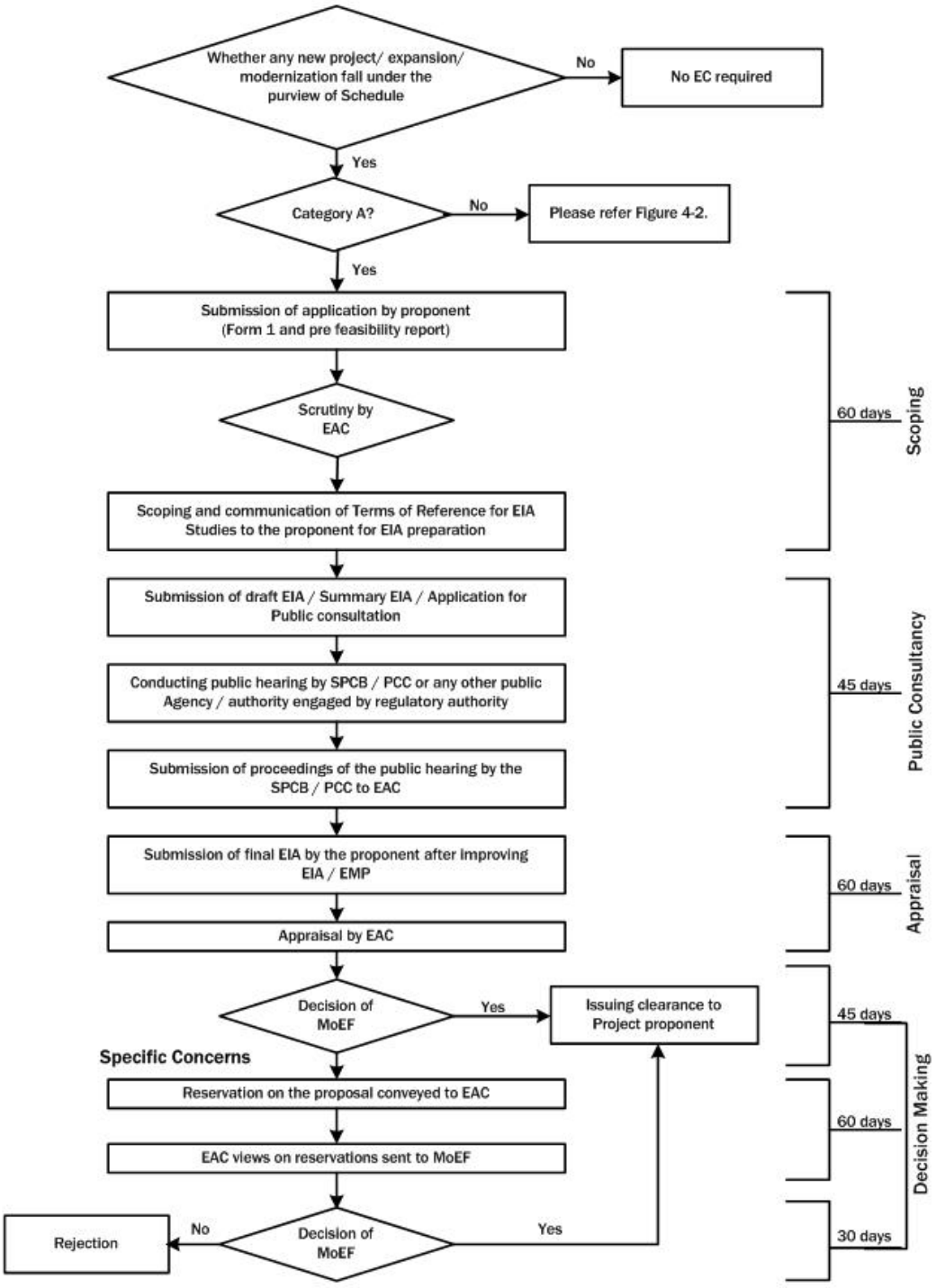


Figure 4-1: Prior Environmental Clearance Process for Activities Falling Under Category A

4.1.1 Application for Prior Screening for Environmental Clearance

- The project proponent, after identifying the site and carrying out a pre-feasibility study, is required to apply for the prior environmental clearance in Form 1 given in

Annexure II. The proponent has to submit the filled in Form 1 along with pre-feasibility report and draft ToR for EIA studies to the concerned Authority *i.e.,* MoEF. Subsequent sections can be referred for the information on how to fill Form 1, contents of pre-feasibility report and sector-specific ToRs.

- Prior environmental clearance is required before any construction work, or preparation of land is started on the identified site/project or activity by the project management, except for securing the land.
- If the application is made for a specific developmental activity, which has an inherent area development component as a part of its project proposal and the same project also attract the construction and area development provisions under 8a and 8b of the Schedule, then the project will be seen as a developmental activity other than 8a and 8b of the Schedule.

4.1.2 Siting Guidelines

These are the guidelines, stakeholders may consider while siting the developmental projects, to minimize the associated possible environmental impacts. While in some situations, completely sticking to these guidelines is difficult and unwarranted, therefore these guidelines may be kept in the background, as far as possible, while taking the decisions.

Areas Preferably be Avoided

In siting industries, care should be taken to minimize the adverse impact of the industries on the immediate neighborhood as well as distant places. Some of the natural life sustaining systems and some specific land uses are sensitive to industrial impacts because of the nature and extent of fragility. With a view to protect such sites, the industries may maintain the following distances as far as possible from the specific areas listed

- Ecologically and/or otherwise sensitive areas (villages, *etc*.): Preferably: 5 km; depending on the geo-climatic conditions the requisite distance may be decided appropriately by the agency.
- Coastal Areas: Preferably ½ km away from high tide line.
- Flood Plain of the Riverine System: Preferably ½ km away from flood plain or modified flood plain affected by dam in the upstream or by flood control systems.
- Transport/Communication System preferably ½ km away from highway and railway.
- Major Settlements (3,00,000 population): Distance from major settlements is difficult to maintain because of urban sprawl. At the time of siting of the industry if the notified limit of any major settlement is found to be within 50 km., from the project boundary, the spatial direction of growth of the settlement for at least a decade must be assessed. Subsequently, the industry shall be sited at least 25 km from the projected growth boundary of the settlement.

Note:

Ecological and/or otherwise sensitive areas include (i) Religious and Historic Places; (ii) Archaeological Monuments (e.g. identified zone around Taj Mahal); (iii) Scenic Areas; (iv) Hill Resorts; (v) Beach Resorts; (vi) Health Resorts; (vii) Coastal Areas rich in Corals, Mangroves, Breeding Grounds of Specific Species; (viii) Estuaries rich in Mangroves, Breeding grounds of Specific Species; (ix) Gulf Areas; (x) Biosphere Reserves; (xi) National Parks and Sanctuaries; (xii) Natural lakes, Swamps; (xiii) Seismic Zones; (xiv) Tribal Settlements; (xv) Areas of Scientific

and Geological Interest; (xvi) Defence Installations, specially those of security importance and sensitive to pollution; (xvii) Border Areas (International) and (xviii) Air Ports.
Pre-requisite: State and Central Governments are required to identify such areas on a priority basis.

General Siting Factors

- In any particular selected site, the following factors must also be recognized.
- No forest land shall be converted into non-forest activity for the sustenance of the industry (Ref: Forest Conversation Act, 1980).
- No prime agricultural land shall be converted into industrial site.
- Land acquired shall sufficiently large to provide space for appropriate treatment of waste water still left for treatment after maximum possible reuse and recycle. Reclaimed (treated) wastewater shall be used to raise green belt and to create water body for aesthetics, recreation, if possible. For industry having odors problem, shall have sufficiently thick green belt surrounding the battery limit of the industries.
- The green belt between two adjoining large scale industries shall be one kilometer.
- Enough space should be provided for storage of recyclable solid wastes so that these could be available for possible reuse.
- Lay out of the industry that may come up in the area must conform to the landscape of the area without affecting the scenic features of that place.
- Associated township of the industry may be created at a space having physiographic barrier between the industry and the township.
- Each industry is required to maintain three ambient air quality measuring stations within 120 degree angle between stations

4.2 Scoping for EIA Studies

Scoping exercise is taken-up soon after the project contours are defined. The primary purpose of scoping is to identify concerns and issues which are important to project decisions. Besides, scoping defines EIA study requirements and boundaries. The results of the scoping exercise form the basis for the rest of the EIA process.

Scoping refers to the process by which the EAC, including applications for expansion and/or modernization of existing projects, determine ToR for EIA studies addressing all relevant environmental concerns for the preparation of an EIA Report for a particular project.

- Project proponent shall submit the application (Form 1, pre-feasibility report and proposed ToR for EIA Studies) to the MoEF. The MoEF consults the EAC to reply to the proponent. The EAC reviews the application form, pre-feasibility report and proposed draft ToR by the proponent and make necessary additions/deletions to make it a comprehensive ToR that suits the statutory requirements for conducting the EIA studies.
    - Precisely, the pre-feasibility report summarizes the project details and also the likely environmental concerns based on the secondary information, which will be availed for filling the Form 1.
    - From the pre-feasibility report and the Form 1, valued environmental components (VECs) may be identified for a given project (the receiving environment/social

components, which are likely to get effected due to the project operations/activities).

- Once the project details from the pre-feasibility report & Form 1; and VECs are identified, a matrix establishing the interactions which can lead to the effects/impacts could be developed (Qualitative analysis).
- For each identified possible effect in the matrix, significance analysis could be conducted to identify the impacts, which needs to be further studied (quantitative analysis) in the subsequent EIA studies. All such points will become the part of the draft ToR to be proposed by the project proponent along with the application form.
- The information to be provided in pre-feasibility report, guidelines for filling Form 1 and guidelines for developing draft ToR is summarized in the subsequent sections.
- Authority consults the respective EAC to reply to the proponent. The EAC reviews the application form, pre-feasibility report and proposed draft ToR by the proponent and make necessary additions/deletions to make it a comprehensive ToR that suits the statutory requirements for conducting the EIA studies.

- A site visit by sub-committees of EAC will be planned, only if considered necessary by the EAC with the written approval of the Chairperson. Project proponent will facilitate such site visits of the sub-committees.
- EAC shall provide an opportunity to the project proponent for presentation and discussions on the proposed project and related issues as well as the proposed ToR for EIA studies. If the State Government desires to present their views on any specific project in the scoping stage, it can depute an officer for the same at the scoping stage to EAC, as an invitee but not as a member of EAC. However, non-appearance of the project proponent before EAC at any stage will not be a ground for rejection of the application for the prior environmental clearance.
- In case of a new or expansion project in an identified problem area by the CPCB, the MoEF may present their views, if any at the stage of scoping, to the EAC.
- The final set of ToRs for EIA studies shall be conveyed to the proponent by the EAC within sixty days of the receipt of Form 1 and Pre-feasibility report. If the finalized ToR for EIA studies are not conveyed to the proponent within sixty days of the receipt of Form 1, the ToR for EIA studies suggested by the proponent shall be deemed as the final and will be approved for the EIA studies.
- The final ToR for EIA studies shall be displayed on the MoEF website.
- Applications for prior environmental clearance may be rejected by the concerned Authority based on the recommendation of the EAC at this stage itself. In case of such rejection, the decision together with reasons for the same shall be communicated to the proponent in writing within sixty days of the receipt of the application.
- The final EIA report and the other relevant documents submitted by the applicant shall be scrutinized by the MoEF strictly with reference to the approved ToR for EIA studies.

4.2.1 Pre-feasibility Report

The pre-feasibility report should include, but not limited to highlight the proposed project information, keeping in view the environmental sensitivities of the selected site, technology options, efficiency and availability. The information required in the pre-

feasibility report varies from case to case even in the same sector depending upon the local environmental setting within which the plant is located. However, the environmental information which may be furnished in the pre-feasibility report for evolving ToR for EIA studies include:

- Description of the project, including in particular:
  - a description of the physical characteristics of the whole project and the land-use requirements during the construction and operational phases,
  - a description of the main characteristics of the production processes, for instance, nature and quantity of the materials used,
  - an estimate, by type and quantity, of expected residues and emissions (water, air and soil pollution, noise, vibration, light, heat, radiation, *etc*.,) resulting from the operation of the proposed project.
- An outline of the main alternatives studied by the developer and an indication of the main reasons for this choice, taking into account the environmental effects.
- A description of the aspects of the environment likely to be significantly affected by the proposed project, including, in particular, population, fauna, flora, soil, water, air, climatic factors, material assets, including the architectural and archaeological heritage, landscape and the inter-relationship between the above factors.
- A description of the likely significant effects of the proposed project on the environment resulting from:
  - the existence of the project,
  - the use of natural resources – Specific consumptions,
  - the emission of pollutants, the creation of nuisances and the elimination of waste, and the description by the developer of the forecasting methods used to assess the effects on the environment.
- A description of the measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment
- A non-technical summary of the information provided under the above headings.
- An indication of any difficulties (technical deficiencies or lack of know-how) encountered by the developer in compiling the required information.

Besides, depending on the scope defined in the pre-feasibility report some pre-feasibility reports are based on various studies, data collection, *etc.,* to address in detail the concern as technical and economical analysis and detailed feasibility level design of equipment, process optimization, economic, financial, social and environmental investigations, cost estimates with detailed bill of quantities (BOQ). The components identified here focuses on the requirements of Scoping for EIA study. **Annexure III** can be referred for preferable structure of the pre-feasibility report.

4.2.2 Guidance for filling information in Form 1

The information given in specifically designed pre-feasibility report for this developmental activity may also be availed for filling Form 1.

Form 1 is designed to help users identify the likely significant environmental effects of proposed projects during scoping. There are two stages for providing information under two columns:

- First - identifying the relevant project activities from the list given in column 2 of Form 1. Start with the checklist of questions set out below and complete Column 3 by answering:
  - Yes - if the activity is likely to occur during implementation of the project;
  - No - if it is not expected to occur;
  - May be - if it is uncertain at this stage whether it will occur or not.
- Second – For each activity for which the answer in Column 3 is "Yes" the next step is to refer to the fourth column which quantifies the volume of activity which could be judged as significant impact on the local environmental characteristics, and identify the areas that could be affected by that activity during construction /operation / decommissioning of the project. The Form 1 requires information within 15 km around the project, whereas actual study area for EIA studies will be as prescribed by EAC. Information will be needed about the surrounding VECs in order to complete this Form 1.

4.2.3 Identification of Appropriate Valued Environmental Components

VECs are components of the natural resources and human world that are considered valuable and are likely to be affected by the project activities. Value may be attributed for economic, social, environmental, aesthetic or ethical reasons. VECs represent the investigative focal point for further EIA process. The indirect and/or cumulative effects can be concerned with indirect, additive or even synergistic effects due to other projects or activities or even induced developments on the same environmental components as would be considered direct effects. But such impacts tend to involve larger scale VECs such as within entire region, river basins or watersheds; and, broad social and economic VECs such as quality of life and the provincial economy. Once VECs are identified then appropriate indicators are selected for impact assessments on the respective VECs.

4.2.4 Methods for Identification of Impacts

There are number of factors which will influence the approach adopted for the assessment of direct, indirect, cumulative impacts, *etc.* for a particular project. The method should be practical and suitable for the project given the data, time and financial resources available. However, the method adopted should be able to provide a meaningful conclusion from which it would be possible to develop, where necessary, mitigation measures and monitoring. Key points to consider when choosing the method(s) include:

- Nature of the impact(s)
- Availability and quality of data
- Availability of resources (time, finance and staff)

The method chosen should not be complex, but should aim at presenting the results in a way that can be easily understood by the developer, decision maker and the public. A comparative analysis of major impact identification methods is given in the following Table 4-1.

Table 4-1: Advantages and Disadvantages of Impact Identification Methods

	Description	Advantages	Disadvantages
Checklists	▪ Annotate the environmental features that need to be	▪ Simple to understand and	▪ Do not distinguish between direct and

	Description	Advantages	Disadvantages
	addressed when identifying the impacts of activities in the project	use ▪ Good for site selection and priority setting ▪ Simple ranking and weighting	indirect impacts ▪ Do not link action and impact ▪ The process of incorporating values can be controversial
Matrices	▪ Grid like table that identify the interaction between project activities (along one axis) and environmental characteristics (along other axis) ▪ Entries are made in the cells which highlights impact severity in the form of symbols or numbers or descriptive comments	▪ Link action to impact ▪ Good method for displaying EIA results	▪ Difficult to distinguish direct and indirect impacts ▪ Significant potential for double-counting of impacts
Networks	▪ Illustrate cause effect relationship of project activities and environmental characteristics ▪ Useful in identifying secondary impacts ▪ Useful for establishing impact hypothesis and other structured science based approaches to EIA	▪ Link action to impact ▪ Useful in simplified form for checking for second order impacts ▪ Handles direct and indirect impacts	▪ Can become very complex if used beyond simplified version
Overlays	▪ Maps the impacts spatially and display them pictorially ▪ Useful for comparing site and planning alternatives for routing linear developments ▪ Can address cumulative effects ▪ Information incentive	▪ Easy to understand ▪ Good to display method ▪ Good siting tool	▪ Address only direct impacts ▪ Do not address impact duration or probability
GIS	▪ Maps the impacts spatially and display them pictorially ▪ Useful for comparing site and planning alternatives for routing linear developments ▪ Can address cumulative effects ▪ Information incentive	▪ Easy to understand ▪ Good to display method ▪ Good siting tool ▪ Excellent for impact identification and analysis	▪ Do not address impact duration or probability ▪ Heavy reliance on knowledge and data ▪ Often complex and expensive
Expert System	▪ Assist diagnosis, problem solving and decision making ▪ Needs inputs from user by answering systematically developed questions to identify impacts and determine their mitigability and significance	▪ Excellent for impact identification and analysis ▪ Good for experimenting	▪ Heavy reliance on knowledge and data ▪ Often complex and expensive

	Description	Advantages	Disadvantages
	▪ Information intensive, high investment methods of analysis		

The project team made an attempt to construct an impact matrix considering major project activities (generic operations) and stage-specific likely impacts which is given in Table 4-2.

While the impact matrix is each project-specific, Table 4-2 may facilitate the stakeholders in identifying a set of components and phase-specific project activities for determination of likely impacts. However, the location-specific concerns may vary from case to case, therefore, the components even without likely impacts are also retained in the matrix for the location-specific reference.

Table 4-2: Matrix of Impacts

			PHASE I						PHASE II								Phase III					Phase IV		
			Pre Commissioning Stage						Construction / Establishment								Operation and Maintenance					Decommissioning		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
ENVIRONMENT	COMPONENT	Project Activities / Parameters/ Factors	Detailed Topographic Survey	Land Acquirement	Site Clearing	Burning of wastes, refuse and cleared vegetation	Site Preparation / Change in Topography	Field Geological Assessments	Civil works such as cutting and filling and building of structures including temporary structures	Heavy Equipment operations	Disposal of construction wastes	Generation of sewage	Influx of construction workers	Deforestation	Transportation of material	Drilling and Casing	Movement of Fuel Reserves	Operation of power source and generator facilities	Storage of chemicals/ flammables	Waste management	Storage and Handling of Crude Oil	Demolishing civil and mechanical structures	Disposal of demolished material	Capping of well heads /drills
PHYSICAL		Erosion Risks								*												*		
		Contamination							*	*	*	*					*					*	*	
	Soil	Soil Quality									*						*					*	*	
	Resources	Fuels/ Electricity																						

			PHASE I						PHASE II								Phase III					Phase IV		
			Pre Commissioning Stage						Construction / Establishment								Operation and Maintenance					Decommissioning		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
		Construction material-stone, aggregates															*							
		Land especially undeveloped or agricultural land																						
		Interruption or Alteration of River Beds					*																	
		Alteration of Hydraulic Regime																						
		Alteration of surface run-off and interflow					*										*							
		Alteration of aquifers					*										*							
	Water	Water quality							*	*		*	*				*					*	*	
	Air	Air quality				*				*	*	*	*				*	*				*	*	
	Noise	Noise								*	*		*				*	*				*		
BIOLOGICAL	Terrestrial Flora	Effect on grass & flowers																						
		Effect on trees & shrubs		*	*	*	*																	
		Effect on farmland																						
		Endangered species							*	*	*	*	*											
		Habitat removal								*	*													

			PHASE I						PHASE II								Phase III					Phase IV		
			Pre Commissioning Stage						Construction / Establishment								Operation and Maintenance					Decommissioning		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
		Contamination of habitats									*											*	*	
	Aquatic biota	Reduction of aquatic biota									*													
	Terrestrial Fauna	Fragmentation of terrestrial habitats											*											
		Disturbance of habitats by noise or vibration									*													
		Reduction of Biodiversity									*		*											
SOCIAL	Economy	Creation of new economic activities	*																					
		Commercial value of properties		*			*																	
		Conflict due to negotiation and/ compensation payments																						
		Generation of temporary and permanent jobs							*	*	*	*	*							*				
		Effect on crops			*	*											*							
		Reduction of farmland productivity			*																			

			PHASE I						PHASE II								Phase III					Phase IV		
			Pre Commissioning Stage						Construction / Establishment								Operation and Maintenance					Decommissioning		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
		Income for the state and private sector		*						*	*											*	*	
	Education	Training in new technologies	*							*	*													*
		Training in new skills to workers	*							*	*	*	*									*		*
	Public Order	Political Conflicts		*	*	*	*												*	*				
		Unrest, Demonstrations & Social conflicts		*																*				
	Infrastructure and Services	Conflicts with projects of urban, commercial or Industrial development	*	*	*	*	*		*	*	*	*	*				*	*	*	*				
	Security and Safety	Increase in Crime									*									*				
		Accidents caused							*	*	*	*	*									*	*	*
	Health	Health							*	*	*	*	*									*	*	*
	Cultural	Land use		*							*												*	
		Recreation									*													
		Aesthetics and human interest							*	*	*	*	*										*	
		Cultural status																		*				

Note:

1. The above table represents a model for likely impacts, which will have to be arrived case-to-case basis considering VECs and significance analysis (Ref Section 2.9).

2. Project activities are shown as indicative for a given sector. However, in Form 1 (application for EIA Clearance), for any question for which answer is 'Yes', then the corresponding activity shall reflect in project activities. Similarly 'parameters'/'factors' will also be changed within a component in order to reflect the target species of prime concern.

4.2.5 Testing the significance of impacts

Certain broad criteria given under should be kept in view while providing the information in column four of the Form 1

1. Will there be a large change in environmental conditions?
2. Will new features be out-of-scale with the existing environment?
3. Will the effect be unusual in the area or particularly complex?
4. Will the effect extend over a large area?
5. Will there be any potential for trans-frontier impact?
6. Will many people be affected?
7. Will many receptors of other types (fauna and flora, businesses, facilities) be affected?
8. Will valuable or scarce features or resources be affected?
9. Is there a risk that environmental standards will be breached?
10. Is there a risk that protected sites, areas, features will be affected?
11. Is there a high probability of the effect occurring?
12. Will the effect continue for a long time?
13. Will the effect be permanent rather than temporary?
14. Will the impact be continuous rather than intermittent?
15. If it is intermittent will it be frequent rather than rare?
16. Will the impact be irreversible?
17. Will it be difficult to avoid, or reduce or repair or compensate for the effect?

For each "Yes" answer in column 3, the nature of effects and reasons for it should be recorded in column 4. The questions are designed so that an "Yes" answer in column 3, will generally point towards the need for analyzing for the significance and requirement for conducting impact assessment for the effect.

4.2.6 Terms of reference for EIA studies

ToR for EIA studies in respect of the offshore and onshore oil and gas exploration, development and production industry may include, but not limited to the following:

4.2.6.1 Offshore

1. Executive summary of the project – giving a *prima facie* idea of the objectives of the proposal, use of resources, justification, *etc*. In addition, it should provide a compilation of EIA report, EMP and the post-project monitoring plan in brief.

Project description

2. Justification for selecting proposed capacity.

3. Geographic information of the site – Latitude/Longitude, total area envisaged for setting up of project, seismic zone classification, *etc.*

4. Maps at appropriate scales with proper labels and legends to illustrate the general settings of project-related development sites as well as surrounding areas likely to be environmentally affected.

5. Details on the implementation of the project in phases *i.e.,* Seismic phase, exploratory drilling phase and development/exploitation.

6. Details on seismic equipments and vessel operations for seismic operations.

7. Details on support infrastructure, vessel and air traffic in the study area.

8. Details on geological, geophysical and seismic surveys.

9. Details on bathymetry such as nature and depth of seabed, *etc*.

10. Complete process flow diagram describing each unit, its processes and operations, along with material and energy inputs and outputs (material, water and energy balance).

11. Details on storage of chemicals at the site and measures to prevent hazards.

12. 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.

13. Details on wastewater generation, treatment and utilization/discharge for produced water, cooling waters, other wastewaters, *etc*. during all project phases.

14. Details on estimation and computation of air emissions (such as nitrogen oxides, sulphur oxides, carbon monoxide, hydrocarbons, VOCs, *etc.*) resulting from flaring, DG sets, combustion, *etc*. during all project phases.

15. Details on oil spills.

16. Identify the Petroleum and Natural Gas Ministries regarding the fulfillment of license requirements.

17. Details on the stratigraphic structure, fracture patterns and seismic history (if any) of the area.

18. Details on projected energy requirement for each phase of the development.

19. Details on change in shoreline due to installation of pipelines and related facilities at the shore.

20. Details on ports and harbors/possibility of expansion of Port facilities due to project activities. (Relevant ToR points from TGM for Ports and Harbors may be referred.)

21. Details on trans-boundary issues, if any.

Description of the environment

22. Baseline data including different components of environment viz. air, noise, water and biology from the study area as mentioned in this manual.

23. Details on climate, meteorology including wind patterns, temperature, rainfall, waves, tides, currents, cyclone, earthquakes, *etc.* in the study area.

24. Details on establishment of baseline on the air quality of the areas immediately affected by the exploratory drilling and also particularly with reference to hydrogen sulphide and sulphur dioxide and background levels of hydrocarbons and VOCs.

25. Details on establishment of baseline on the water resources of the area affected or potentially impacted by the activities in the various phases of the project. This baseline should include water quality assessment of available waters sources of the project site and zone of influence. The baseline should potentially include parameters such as: Total Nitrate, Salinity, DO, COD, BOD, pH, Sulphates, Hardness, Phosphates, Conductivity, Heavy metals (Total metals, mercury, lead, copper *etc.*), TDS, Hydrocarbons and Arsenic.

26. Quantify noise and vibration levels to be expected from seismic activities and potential exploratory drilling.

27. Details on bathymetry including sea depth, seawater quality, seafloor relief, navigational information, digital terrain model, *etc*.

28. Details of the basic physical environment of the study area.

29. Studies on flora and fauna including the main habitat types with list of species of flora and fauna and their conservation value, giving particular attention to any species protected under law.

30. Fisheries study w.r.t. benthos and marine organic material and coastal fisheries.

31. Details on the nature and volumes of liquid waste (including sewage if applicable), and wastewater and other sources of runoff to be generated by the project activities.

32. Details on the nature and volumes of solid wastes, including seismic programme by-products, drilling mud, drill cuttings *etc.,* to be generated by the project activities.

33. Identification of CRZ area: A CRZ map duly authenticated by one of the authorized agencies demarcating LTL, HTL, CRZ area, location of the project and associate facilities w.r.t. CRZ, coastal features such as mangroves, if any. The route of the pipeline, *etc*., passing through CRZ, if any, should also be demarcated. The recommendations of the State Coastal Management Authority for the activities to be taken up in the CRZ. The CRZ map in 1:10000 scale in general cases and in 1:5000 scale for specific observations.

34. If ecologically sensitive attributes fall with in 10 km from the project boundary, proponent shall describe the sensitivity (distance, area and significance) and propose the additional points based on significance for review and acceptance by the EAC. Ecological sensitive attributes include:

    - Breeding grounds
    - Core zone of biosphere reserve
    - Mangrove area
    - Areas with threatened (rare, vulnerable, endangered) flora/fauna
    - Protected corals

35. Details on hazardous or toxic material or substance to be used during either seismic testing or potential exploratory drilling.

36. Capital quantity of dredging material, disposal and its impact on aquatic life.

Anticipated Environmental Impacts & Mitigation Measures

37. Details on potential impacts of seismic and exploratory drilling activities on water quality within the study area.

38. Details on potential impacts of project activities on the air emissions resulting from drilling operations.

39. Details on potential impacts on the water quality due to the activities in the various phases of the project.

40. Details on noise and vibration levels quantification that is expected from seismic activities and potential exploratory drilling and specify any potential impacts of these on the surrounding environment including human habitation.

41. Details on odor sources (such as hydrogen sulphide, mercaptants, *etc.*) and mitigation measures taken to control the odour.

42. Details on potential impacts of project activities on the aquatic fauna and flora for each phase of the project.

43. Details on impact of spills and discharge of crude oil in the surrounding areas.

44. Details on impacts of drilling waste such as drilling mud, additives (polymers, oxygen scavengers, biocides, surfactants), lubricants, diesel oil, emulsifying agents, flocculating agents, *etc*. and its treatment and disposal options to control the impacts.

45. Details on environmental impacts of the decommissioning of oil and gas installations, drill cuttings, *etc*.

46. Describe mitigation measures including an EMP to be implemented to reduce or offset the adverse impacts of seismic testing, potential exploratory drilling and exportation. Also, include measures to be taken during decommissioning phase.

47. Prepare outline designs for any proposals and give costs for implementing the mitigation measures.

48. Identify the preferred option(s) for waste management/disposal method based on environmental grounds, including necessary infrastructure. Specify any residual impacts of waste management, their significance, and any mitigation measures to be undertaken.

49. Identify mitigation measures to reduce or limit the potential impact on the surrounding environment and zone of influence (humans and wildlife).

50. Details on occupational health and safety of employees and workers.

51. Details on oceanographic changes (such as induced currents, waves, tidal currents, water quality, *etc*.) due to infrastructure development for project activities.

52. Recommend precise mitigation measures based on the specific option selected, for the proper management of all types of traffic close to and within the project area. These mitigation measures must include recommendations for protection features against erosion, and other potential pollution to the environment as well as social and human impacts.

53. Describe the potential social, economic and cultural impacts of conducting the proposed activity. Characterize the impacts in terms of type (beneficial or adverse), magnitude (high, medium or low), direct/indirect, duration (short, medium and long term, sporadic), avoidance and reversibility.

54. Typical measures that could be considered for the mitigation of impacts as given in this manual may be referred.

55. Impact of the activities to be taken up in the CRZ area including jetty and desalination plant etc., should be integrated into the EIA report; however, action should be taken to obtain separate clearance from the competent authority as may be applicable to such activities.

Analysis of Alternative resources and technologies

56. Evaluate options for the provision of suitable access for each of the components of the exploration phase.

57. Select preferred option for the provision for these components. This may need to examine construction materials (types, sources, volumes, transportation) and methods in relation to their environmental impacts.

58. Evaluate alternative options for meeting project needs. For these options, it may be necessary to investigate:

- fuel storage (where relevant)
- transportation (where relevant)
- health and safety
- significance of any pollution that may result from energy generation; and
- mitigation measures

59. Select the preferred option for energy generation. Again, this should be based on environmental grounds, and should specify the residual impacts of generation of the preferred option, their significance and the mitigation measures, which will be undertaken.

60. Evaluate alternative options for the collection, treatment, recycling (if appropriate), and disposal of these wastes. Identify any chemicals planned for use in the treatment or management of these wastes.

61. Details on improved technologies such as remote sensing and GIS, *etc*. in oil and gas exploration.

Environmental Monitoring Program

62. Details on environmental monitoring program during surveying, drilling and exploration.

63. Details on use of advanced monitoring technologies such as remote sensing, *etc*., if any.

64. Identify and develop a water quality monitoring program able to detect any change in groundwater or surface water quality that could impact:

    - Public health
    - Forest, wetland and adjacent aquatic habitats; and
    - Flora and Fauna (including endangered or threatened species) in project area and zone of influence.

65. Develop and Implement an air quality monitoring programme to monitor the release of toxic emission in particular SO_2, CO and NO_2 and their potential impacts on Public Health, wildlife health and environment.

66. Appropriate monitoring network has to be designed and proposed for regulatory compliance and to assess the residual impacts, if any.

Additional Studies

67. Details on existing socio-economic conditions with a brief overview of the socio-economic background to the study area, including population, employment and travel patterns.

68. Identify patterns of land use within the corridor of the proposed route, and record these on a map with annotation.

69. Consult with relevant local stakeholders (village councils, local community, and local NGOs) within the direct project area, to identify their economical, environmental and social concerns about the proposal.

70. Archaeology - Consult with the Archeology Department to conduct a general assessment of the area to determine any features of archaeological or cultural importance and provide recommendations for the protection of any features.

71. Public Interest - Report on the views and concerns of directly affected communities, local NGOs and relevant government departments/agencies regarding the development of the project.

72. Details on risk assessment including identification of hazards, proposed measures, disaster management plan, contingency plan, emergency response plan, *etc.*.

Environmental Management Plan

73. Outline of the overall management structure anticipated for the proposed activities.

74. Details on compliance verification of the emissions of the environmental components (such as emissions limits, discharge limits, noise limits, odor, *etc.*) with the national/ international standards.

75. Description of the pertinent regulations, standards and policies, at the local and national levels governing environmental quality, health, safety and protection of sensitive areas. These could include cultural resources, protection of endangered or threatened species, infrastructure development and land use control that may have an impact on the proposed development.

76. Specify options for refueling of vehicles and identify best practice methods for eliminating spills and maximizing health and safety.

77. Identify emergency preparation and applicable management measures for the proposed activities dealing with the following eventualities:

    - Oil spills
    - Hurricanes
    - Floods
    - Fires
    - Blow out plan
    - Hydrogen sulfide safety (including other types of gases)
    - Employee training

78. Details on post project closure and monitoring programme.

4.2.6.2 Onshore

1. Executive summary of the project – giving a *prima facie* idea of the objectives of the proposal, use of resources, justification, *etc.* In addition, it should provide a compilation of EIA report, EMP and the post-project plan in brief.

Project Description

2. Justification for selecting the proposed capacity.

3. Geographic information of the site – Latitude/Longitude, total area envisaged for setting up of project, seismic zone classification, topography, *etc*.

4. Land requirement for the project including its optimization, break up of land requirement and its availability.

5. Maps at appropriate scales with proper labels and legends to illustrate the general settings of project-related development sites as well as surrounding areas likely to be environmentally affected.

6. Details on the implementation of the project in phases *i.e*., Seismic phase, exploratory drilling phase and development/exploitation.

7. Complete process flow diagram describing each unit, its processes and operations, along with material and energy inputs and outputs (material, water and energy balance).

8. Details on support infrastructure in the study area.

9. Details on geological, geophysical and seismic surveys.

10. Details on outline of the overall management structure anticipated for the proposed activities.

11. Details on the implementation of the project in phases *i.e.*, Seismic phase, exploratory drilling phase and development/exploitation

12. 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.

13. Details on wastewater generation, treatment and utilization/discharge for produced water, cooling waters, other wastewaters, *etc*. during all project phases.

14. Details on estimation and computation of air emissions (such as nitrogen oxides, sulphur oxides, carbon monoxide, hydrocarbons, VOCs, *etc*.) resulting from flaring, DG sets, combustion, etc. during all project phases.

15. Identify the Petroleum and Natural Gas Ministries regarding the fulfillment of license requirements.

16. Details on the stratigraphic structure, fracture patterns and seismic history (if any) of the area.

17. Details on projected energy requirement for each phase of the development.

Description of the Environment

18. Baseline data including different components of environment viz. air, noise, water and biology from the study area as mentioned in this manual.

19. Details on demography and socio-economic status in the study area.

20. Details on establishment of baseline on the air quality of the areas immediately affected by the exploratory drilling and also particularly with reference to hydrogen sulphide and sulphur dioxide and background levels of hydrocarbons (HC) and VOCs.

21. Details on establishment of baseline on the water resources of the area. This baseline should include water quality assessment of available waters sources of the project site and zone of influence. The baseline should potentially include parameters such as: Total Nitrate, Salinity, DO, COD, BOD, pH, Sulphates, Hardness, Phosphates, Conductivity, Heavy metals (Total metals, mercury, lead, copper *etc.*), TDS, Hydrocarbons and Arsenic.

22. Quantify noise and vibration levels to be expected from seismic activities and potential exploratory drilling.

23. Details of the basic physical environment of the study are. This should include:

    - Topography: including degree of slopes, drainage patterns around project site, and flood hazard
    - Map outlining the boundaries of area of influence in relation to protected areas, surrounding villages, roads, *etc.*
    - Climate, Hydrology and Meteorology: including rainfall average per year, prevailing wind patterns
    - Geology: description of the characteristics of landform, land surface including exposed rocks, types of unconsolidated materials sediments, rivers, tributaries, if they can be determined by field mapping
    - Soils: specific soil types ,soil fertility, agricultural value

24. Land use of the proposed study area as well as the project area – notified industrial area, residential/ institutional/nearest village/ township/ locality/ housing society, grazing, mangroves, no development area, national parks, sanctuary, marches, surface water bodies, roads, protected areas, agriculture, tourism, *etc.* based on the satellite imagery.

25. Maps at appropriate scales and with proper labels and legends to illustrate the general settings of project-related development sites as well as surrounding areas likely to be environmentally affected.

26. Air Quality - Details on baseline of air quality of the areas immediately affected by the exploratory drilling.

27. Physical description of surrounding water bodies including creeks and rivers.

28. Studies on flora and fauna including the main habitat types with list of species of flora and fauna and their conservation value, giving particular attention to any species protected under law

29. Details on baseline on the current presence of hydrocarbons and heavy metals in the soils.

30. If any incompatible land use attributes fall with in 10 km from the project boundary, proponent shall describe the sensitivity (distance, area and significance) and propose the additional points based on significance for review and acceptance by the EAC. Incompatible land use attributes include:

- Public water supply areas from rivers/surface water bodies, from groundwater
- Scenic areas/tourism areas/hill resorts
- Religious places, pilgrim centers that attract over 10 lakh pilgrims a year
- Protected tribal settlements (notified tribal areas where industrial activity is not permitted)
- Monuments of national significance, World Heritage Sites
- Cyclone, Tsunami prone areas (based on last 25 years)
- Airport areas
- Any other feature as specified by the State or local government and other features as locally applicable, including prime agricultural lands, pastures, migratory corridors *etc.*

31. If ecologically sensitive attributes fall with in 10 km from the project boundary, proponent shall describe the sensitivity (distance, area and significance) and propose the additional points based on significance for review and acceptance by the EAC. Ecological sensitive attributes include:

    - National parks
    - Wild life sanctuaries Game reserve
    - Tiger reserve/elephant reserve/turtle nesting ground
    - Breeding grounds
    - Core zone of biosphere reserve
    - Habitat for migratory birds
    - Mangrove area
    - Areas with threatened (rare, vulnerable, endangered) flora/fauna
    - Protected corals
    - Wetlands
    - Zoological gardens
    - Gene Banks
    - Reserved forests
    - Protected forests
    - Any other closed/protected area under the Wild Life (Protection) Act, 1972, any other area locally applicable.

32. If the location falls in a valley, specific issues connected to the management of natural resources shall be studied.

33. Determine the nature and volumes of liquid waste (including sewage if applicable), and wastewater and other sources of runoff to be generated by the entire project.

34. Determine the nature and volumes of solid wastes, including seismic programme by-products, drilling mud, drill cuttings *etc.*, to be generated by the entire project.

35. Quantify whether any of the solid waste are to be considered hazardous or not.

36. Details on hazardous or toxic chemical material or substance to be used during either seismic testing or potential exploratory drilling.

Anticipated Environmental Impacts & Mitigation Measures

37. Describe and identify potential impacts on the terrestrial and aquatic fauna and flora of the study area for each phase. This would include, where applicable, forest, river corridors, wetlands, biological corridors, and protected areas.

38. If clearing of vegetation is required, estimate the acreage.

39. Details on potential impacts of seismic and exploratory drilling activities on water quality within the study area.

40. Details on potential impacts of project activities on the air emissions resulting out of drilling operations.

41. Details on potential impacts on the water quality due to the activities in the various phases of the project.

42. Details on noise and vibration levels quantification that is expected from seismic activities and potential exploratory drilling and specify any potential impacts of these on the surrounding environment including human habitation.

43. Details on odour sources (such as hydrogen sulfide, mercaptans *etc*) and mitigation measures taken to control the odour.

44. Details on impact of spills and discharge of crude oil in the surrounding areas.

45. Details on impacts of drilling waste such as drilling mud, additives (polymers, oxygen scavengers, biocides, surfactants), lubricants, diesel oil, emulsifying agents, flocculating agents, *etc*. and its treatment and disposal options to control the impacts.

46. Details on environmental impacts of the decommissioning of oil and gas installations, drill cuttings, *etc*.

47. Describe mitigation measures including an EMP which is to be implemented to reduce or offset the adverse impacts of seismic testing, potential exploratory drilling and exportation. Also, include measures to be taken during decommissioning phase.

48. Details on outline designs for any proposal and costs for implementing the mitigation measures.

49. Identify the preferred option(s) for waste management/disposal method based on environmental grounds, including necessary infrastructure. Specify any residual impacts of waste management, their significance, and any mitigation measures to be undertaken.

50. Identify mitigation measures to reduce or limit the potential impact on the surrounding environment and zone of influence (humans and wildlife).

51. Details on occupational health and safety of employees and workers.

52. Recommend precise mitigation measures based on the specific option selected, for the proper management of all types of traffic close to and within the project area. These mitigation measures must include recommendations for protection features against erosion, and other potential pollution to the environment as well as social and human impacts.

53. Describe the potential social, economic and cultural impacts of conducting the proposed activity. Characterize the impacts in terms of type (beneficial or adverse), magnitude (high, medium or low), direct/indirect, duration (short, medium and long term, sporadic), avoidance and reversibility.

54. Typical measures that could be considered for the mitigation of impacts as given in this manual may be referred.

Analysis of alternative resources and technologies

55. Evaluate options for the provision of suitable access for each of the components of the exploration phase.

56. Select preferred option for the provision for exploration phase components. This may need to examine construction materials (types, sources, volumes, transportation) and methods in relation to their environmental impacts.

57. Evaluate alternative options for meeting project needs. For these options, it may be necessary to investigate:

    - fuel storage (where relevant)
    - transportation (where relevant)
    - health and safety
    - significance of any pollution that may result from energy generation; and
    - mitigation measures

58. Select the preferred option for energy generation. Again, this should be based on environmental grounds, and should specify the residual impacts of generation of the preferred option, their significance and the mitigation measures, which will be undertaken.

59. Evaluate alternative options for the collection, treatment, recycling (if appropriate), and disposal of these wastes. Identify any chemicals planned for use in the treatment or management of these wastes.

60. Details on improved technologies such as remote sensing and GIS, *etc.* in oil and gas exploration.

Environmental Monitoring Program

61. Details on environmental monitoring program during surveying, drilling and exploration.

62. Details on use of advanced monitoring technologies such as remote sensing, *etc*., if any.

63. Identify and develop a water quality monitoring program able to detect any change in groundwater or surface water quality that could impact:

    - Public health
    - Forest, wetland and adjacent aquatic habitats; and
    - Flora and Fauna (including endangered or threatened species) in project area and zone of influence.

64. Develop and Implement an air quality monitoring programme to monitor the release of toxic emission in particular SO_2, CO and NO_2 and their potential impacts on Public Health, wildlife health and environment.

65. Appropriate monitoring network has to be designed and proposed for regulatory compliance and to assess the residual impacts, if any.

Additional Studies

66. Details on existing socio-economic conditions, giving a brief overview of the socio-economic background to the study area, including population, employment and travel patterns.

67. Identify patterns of land use within the corridor of the proposed route, and record these on a map with annotation.

68. Consult with relevant local stakeholders (village councils, local community, and local NGOs) within the direct project area, to identify their economical, environmental and social concerns about the proposal.

69. Archaeology - Consult with the Archeology Department to conduct a general assessment of the area to determine any features of archaeological or cultural importance and provide recommendations for the protection of any features.

70. Public Interest - Report on the views and concerns of directly affected communities, local NGOs and relevant government departments/agencies regarding the development of the project.

71. Details on risk assessment including identification of hazards, proposed measures, disaster management plan, contingency plan, emergency response plan, *etc*.

Environmental Management Plan

72. Outline of the overall management structure anticipated for the proposed activities.

73. Details on compliance verification of the emissions of the environmental components (such as emissions limits, discharge limits, noise limits, odor, *etc.*) with the national/ international standards.

74. Description of the pertinent regulations, standards and policies, at the local and national levels governing environmental quality, health, safety and protection of sensitive areas. These could include cultural resources, protection of endangered or threatened species, infrastructure development and land use control that may have an impact on the proposed development.

75. Specify options for refueling of vehicles and identify best practice methods for eliminating spills and maximizing health and safety.

76. Identify emergency preparation and applicable management measures for the proposed activities dealing with the following eventualities:

    - Oil spills
    - Hurricanes
    - Floods
    - Fires
    - Blow out plan
    - Hydrogen sulfide safety (including other types of gases)

- Employee training

4.3 Environmental Impact Assessment

The approach for accomplishing EIA studies is shown in figure 4.2. Each stage is discussed, in detail in subsequent sections.

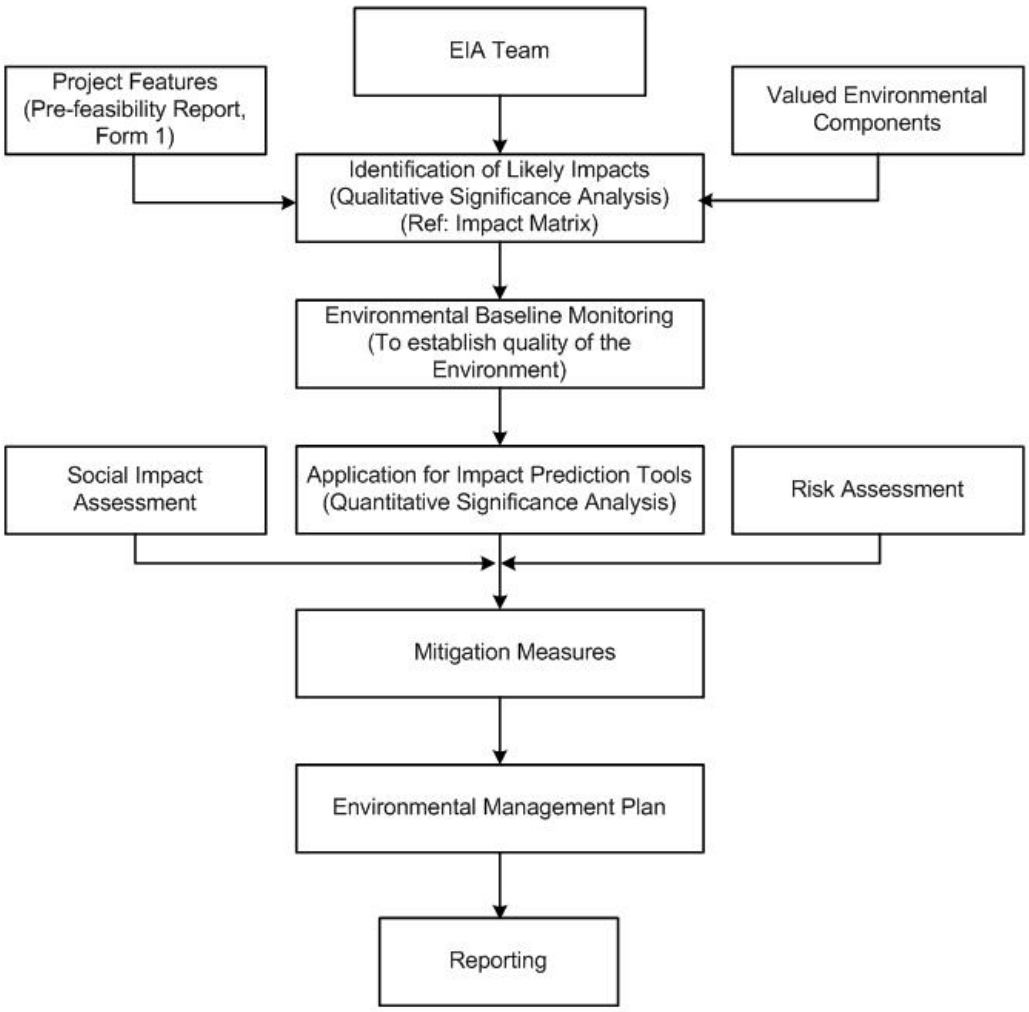


Figure 4-2: Approach for EIA Study

4.3.1 EIA Team

The success of a multi-functional activity like an EIA primarily depends on constitution of a right team at the right time (preferable at the initial stages of an EIA) in order to assess the significant impacts (direct, indirect as well as cumulative impacts).

The professional Team identified for a specific EIA study should consist of qualified and experienced professionals from various disciplines in order to address the critical aspects identified for the specific project. Based on the nature and the environmental setting, following professionals may be identified for EIA studies.

- Environmental management specialist/Regulator
- Air and noise quality expert
- Occupational health
- Geology/geo-hydrology
- Ecologist
- Transportation Specialist
- Safety and health specialist
- Social scientist
- Crude Extraction and processing
- Chemical Engineer
- Marine Biologist/Engineer, e*tc*

4.3.2 Baseline Quality of the Environment

EIA Notification 2006 typically specifies that an EIA Report should contain a description of the existing environment that would be or might be affected directly or indirectly by the proposed project. Environmental Baseline Monitoring (EBM) is a very important stage of EIA. On one hand EBM plays a very vital role in EIA and on the other hand it provides feedback about the actual environmental impacts of a project. EBM during the operational phase helps in judging the success of mitigation measures in protecting the environment. Mitigation measures, in turn are used to ensure compliance with environmental standards, and to facilitate any needed project design or operational changes.

The existing environment is broadly defined to include the natural, cultural, socio-economic systems and their interrelationships. The intention is not to describe all baseline conditions, but to focus the collection and description of baseline data on those VECs that are important and are likely to be affected by the proposed offshore and onshore oil and gas exploration project activities.

4.3.2.1 Objective of EBM in the EIA Context

The term ‘baseline’ refers to conditions existing before development against which subsequent changes can be referenced. EBM studies are carried out to:

- Identify environmental conditions which might influence project design decisions (e.g., site layout, structural or operational characteristics);
- Identify sensitive issues or areas requiring mitigation or compensation;
- Provide input data to analytical models used for predicting effects;
- Provide baseline data against which the results of future monitoring programs can be compared.

At this stage of EIA process, the EBM is primarily discussed in the context of first purpose wherein the feedback from EBM programs may be used to:

- Determine the available assimilative capacity of different environmental components within the designated impact zone and whether more or less stringent mitigation measures are needed; and
- Improve the predictive capability of EIAs.

There are many institutional, scientific, quality control, and fiscal issues that must be addressed in the implementation of an environmental monitoring program. Careful consideration of these issues in the design and planning stages will help avoid many of the pitfalls associated with environmental monitoring programs.

4.3.2.2 Environmental Monitoring Network Design

Monitoring refers to the collection of data through a series of repetitive measurements of environmental parameters (or, more generally, to a process of systematic observation). The environmental quality monitoring programme design will be dependent upon the monitoring objectives specified for the selected area of interest. Types of monitoring and network design considerations are discussed in **Annexure IV**.

4.3.2.3 Baseline Data Generation

List of important physical environmental components and indicators of EBM are given in Table 4-3.

Table 4-3: List of Important Physical Environment Components and Indicators of EBM

Environmental Component	Environmental Indicators
Climatic variables	- Rainfall patterns – mean, mode, seasonality - Temperature patterns - Extreme events - Climate change projections - Prevailing wind - direction, speed, anomalies - Stability conditions and mixing height
Geology	- Underlying rock type - Surgical material - Geologic structures (faults *etc*.) - Geologic resources (minerals, *etc*.)
Topography	- Slope form - Landform and terrain analysis - Specific landform types
Coastal dynamics and morphology	- Wave patterns - Currents - Shoreline morphology – near shore, foreshore - Sediment – characteristics and transport
Soil	- Type and characteristics - Porosity and permeability - Sub-soil permeability - Run-off rate - Effective depth (inches/centimeters) - Inherent fertility - Suitability for method of sewage disposal
Drainage	- Surface hydrology - Drainage network - Rainfall runoff relationships

Environmental Component	Environmental Indicators
	- Hydrogeology - Groundwater characteristics – springs, *etc*.
Water quality	- Terrestrial - rivers, lakes, ponds, gullies - Coastal
Air quality	- Ambient - Respirable - Airshed importance - Odour levels
Noise	- Ambient
Hazardous waste	-

Guidance for assessment of baseline components and attributes describing sampling network, sampling frequency, method of measurement is given in **Annexure V**.

Infrastructure Requirements for EBM

In addition to devising a monitoring network design and monitoring plans/program, it is also necessary to ensure adequate resources in terms of staffing and skills, equipment, training, budget, *etc*., for its implementation. Besides assigning institutional responsibility, reporting requirements, QA/QC plans and its enforcement capability are essential. A monitoring program that does not have an infrastructural support and QA/QC component will have little chance of success.

Defining Data Statistics/Analyses Requirements

The data analyses to be conducted are dictated by the objectives of the environmental monitoring program. The statistical methods used to analyze the data should be described in detail prior to data collection. This is important because repetitive observations are recorded in time and space. Besides, the statistical methods could also be chosen so that uncertainty or error estimates in the data can be quantified. For e.g., statistical methods useful in an environmental monitoring program include: 1) frequency distribution analysis; 2) analysis of variance; 3) analysis of covariance; 4) cluster analysis; 5) multiple regression analysis; 6) time series analysis; 7) the application of statistical models (ADB-Green, 1979).

Use of Secondary Data

The EBM program for EIA can at best address temporal and/or spatial variations limited to a limited extent because of cost implications and time limitations. Therefore analysis of all available information or data is essential to establish the regional profiles. So all the relevant secondary data available for different environmental components should be collated and analyzed.

To facilitate stake-holders, IL&FS Ecosmart Ltd. made an attempt to compile the list of information required for EIA studies. Respective sources of secondary data are provided in **Annexure VIA** and **Annexure VIB.**

Impact Prediction Tools

The scientific and technical credibility of an EIA relies on the ability of the EIA practitioners to estimate the nature, extent, and magnitude of change in environmental components that may result from project activities. Information about predicted changes is needed for assigning impact significance, prescribing mitigation measures, and designing and developing EMPs and monitoring programs. The more accurate the predictions, the more confident the EIA practitioner will be in prescribing specific measures to eliminate or minimize the adverse impacts of development project.

Choice of models/methods for impact predictions in respect of each of air, noise, water, land and biological environment are precisely tabulated in **Annexure VII**.

4.3.3 Significance of Impacts

Evaluating the significance of environmental effects is perhaps the most critical component of impact analysis. More than other components, however, the interpretation of significance is also a contentious process. The interpretation of significance bears directly on the subsequent EIA process and also during Environmental Clearance on project approvals and condition setting. At an early stage, it also enters into screening and scoping decisions on what level of assessment is required and which impacts and issues will be addressed.

Impact significance is also a key to choosing among alternatives. In sum, the attribution of significance continues throughout the EIA process, from scoping to EIS review, in a gradually narrowing "cone of resolution" in which one stage sets up the next. But at this stage it is the most important as better understanding and quantification of impact significance is required.

One common approach is based on determination of the significance of predicted changes in the baseline environmental characteristics and compares these with reference to regulatory standards, objective criteria and similar 'thresholds' as eco-sensitivity, cultural /religious values. A better test proposed by the CEAA (1995) is to determine if 'residual' environmental effects are adverse, significant, and likely (given under). But at this stage, the practice of formally evaluating significance of residual impacts, *i.e.*, after predicting the nature and magnitude of impacts based on before-versus-after-project comparisons, and identifying measures to mitigate these effects is not being followed in a systematic way.

Step 1: Are the environmental effects adverse?

Criteria for determining if effects are "adverse" include:

- effects on biota health
- effects on rare or endangered species
- reductions in species diversity
- habitat loss
- transformation of natural landscapes
- effects on human health
- effects on current use of lands and resources for traditional purposes by aboriginal persons; and
- foreclosure of future resource use or production

Step 2: Are the adverse environmental effects significant?

Criteria for determining 'significance' is to judge that the impacts:

- are extensive over space or time
- are intensive in concentration or proportion to assimilative capacity
- exceed environmental standards or thresholds
- do not comply with environmental policies, land use plans, sustainability strategy
- adversely and seriously affect ecologically sensitive areas
- adversely and seriously affect heritage resources, other land uses, community lifestyle and/or indigenous peoples traditions and values

Step 3: Are the significant adverse environmental effects likely?

- Criteria for determining 'likelihood' include:
- probability of occurrence, and
- scientific uncertainty

4.4 Social Impact Assessment

Social impact assessment is the instrument used to analyze social issues and solicit stakeholder views for the design of projects. Social assessment helps make the project responsive to social development concerns, including seeking to enhance benefits for poor and vulnerable people while minimizing or mitigating risk and adverse impacts. It analyzes distributional impacts of intended project benefits on different stakeholder groups, and identifies differences in assets and capabilities to access the project benefits.

The scope and depth of the social assessment should be determined by the complexity and importance of the issues studied, taking into account the skills and resources available. However, social impact assessment may include following:

Description of the Socio-economic, Cultural and Institutional Profile

Conduct a rapid review of available sources of information to describe the socio-economic, cultural and institutional interface in which the project operates.

Socio-economic and cultural profile: Describe the most significant social, economic and cultural features that differentiate social groups in the project area. Describe their different interests in the project, and their levels of influence. In particular, explain any particular effects the project may have on the poor and underprivileged. Identify any known conflicts among groups that may affect project implementation.

Institutional profile: Describe the institutional environment; consider both the presence and function of public, private and civil society institutions relevant to the operation. Are there important constraints within existing institutions e.g. disconnect between institutional responsibilities and the interests and behaviors of personnel within those institutions? Or are there opportunities to utilize the potential of existing institutions, e.g. private or civil society institutions, to strengthen implementation capacity

Legislative and Regulatory Considerations

To review laws and regulations governing the project's implementation and the access of poor and excluded groups to goods, services and opportunities provided by the project. In addition, review the enabling environment for public participation and development planning. Social analysis should build on strong aspects of the legal and regulatory systems to facilitate program implementation and identify weak aspects while recommending alternative arrangements.

Key Social Issues

The social analysis provides the baseline information for designing the social development strategy. The analysis should determine what the key social and Institutional issues are in relation to project objectives; identify the key stakeholder groups in this context and determine how relationships between stakeholder groups will affect or be affected by the project; and identify expected social development outcomes and actions proposed to achieve those outcomes.

Data Collection and Methodology

Describe the design and methodology for the social analysis. In this regard:

- Build on existing data;
- Clarify the units of analysis for the social assessment: intra-household, household level, as well as communities/settlements and other relevant social aggregations on which data is available or will be collected for analysis;
- Choose appropriate data collection and analytical tools and methods, employing mixed methods wherever possible; mixed methods include a mix of quantitative and qualitative methods.

Strategy to Achieve Social Development Outcomes

Identify the likely social development outcomes of the project and propose a Social development strategy, including recommendations for institutional arrangements to achieve them, based on the findings of the social assessment. The social development strategy could include measures:

- that strengthen social inclusion by ensuring that both poor and excluded groups and intended beneficiaries are included in the benefit stream and in access to opportunities created by the project
- that empower stakeholders through their participation in the design and implementation of the project, their access to information, and their increased voice and accountability (*i.e.* a participation framework); and
- that enhance security by minimizing and managing likely social risks and increasing the resilience of intended beneficiaries and affected persons to socioeconomic shocks

Implications for Analysis of Alternatives

Review the proposed approaches for the project, and compare them in terms of their relative impacts and social development outcomes. Consider what implications the findings of the social assessment might have on those approaches. Should some new components be added to the approach, or other components reconsidered or modified?

If the social analysis and consultation process indicate that alternative approaches are likely to have better development outcomes, such alternatives should be described and considered, along with the likely budgetary and administrative effects these changes might have.

Recommendations for Project Design and Implementation Arrangements

Provide guidance to project management and other stakeholders on how to integrate social development issues into project design and implementation arrangements. As much as possible, suggest specific action plans or implementation mechanisms to address relevant social issues and potential impacts. These can be developed as integrated or separate action plans, for example, as Resettlement Action Plans, Indigenous Peoples Development Plans, Community Development Plans, *etc.*

Developing a Monitoring Plan

Through the social assessment process, a framework for monitoring and evaluation should be developed. To the extent possible, this should be done in consultation with key stakeholders, especially beneficiaries and affected people. The framework shall identify expected social development indicators, establish benchmarks, and design systems and mechanisms for measuring progress and results related to social development objectives. The framework shall identify organizational responsibilities in terms of monitoring, supervision, and evaluation procedures. Where possible, participatory monitoring mechanisms shall be incorporated. The framework should

- Establish a set of monitoring indicators to track the progress achieved. The benchmarks and indicators should be limited in number, and should combine both quantitative and qualitative types of data. The indicators should include outputs to be achieved by the social development strategy; indicators to monitor the process of stakeholder participation, implementation and institutional reform;
- Establish indicators to monitor social risk and social development outcomes; and indicators to monitor impacts of the project's social development strategy. It is important to suggest mechanisms through which lessons learned from monitoring and stakeholder feedback can result in changes to improve the operation of the project. Indicators should be of such a nature that results and impacts can be disaggregated by gender and other relevant social groups;

Define transparent evaluation procedures. Depending on context, these may include a combination of methods, such as participant observation, key informant interviews, focus group discussions, census and socio-economic surveys, gender analysis, Participatory Rural Appraisal (PRA), Participatory Poverty Assessment (PPA) methodologies, and other tools. Such procedures should be tailored to the special conditions of the project and to the different groups living in the project area; Estimate resource and budget requirements for monitoring and evaluation activities, and a description of other inputs (such as institutional strengthening and capacity building) needed to carry it out.

4.5 Risk Assessment

Industrial accidents results in great personal and financial loss. Managing these accidental risks in today's environment is the concern of every industry including the proposed industry, because either real or perceived incidents can quickly jeopardize the financial viability of a business. Many facilities involve various manufacturing processes that have

the potential for accidents which may be catastrophic to the plant, work force, environment, or public.

The main objective of the risk assessment study is to propose a comprehensive but simple approach to carry out risk analysis and conducting feasibility studies for industries and planning and management of industrial prototype hazard analysis study in Indian context.

Risk analysis and risk assessment should provide details on Quantitative Risk Assessment (QRA) techniques used world-over to determine risk posed to people who work inside or live near hazardous facilities, and to aid in preparing effective emergency response plans by delineating a Disaster Management Plan (DMP) to handle onsite and offsite emergencies. Hence, QRA is an invaluable method for making informed risk-based process safety and environmental impact planning decisions, as well as being fundamental to any facility-siting decision-making. QRA whether, site-specific or risk-specific for any plant is complex and needs extensive study that involves process understanding, hazard identification, consequence modeling, probability data, vulnerability models/data, local weather and terrain conditions and local population data. QRA may be carried out to serve the following objectives.

- Identification of safety areas
- Identification of hazard sources
- Generation of accidental release scenarios for escape of hazardous materials from the facility
- Identification of vulnerable units with recourse to hazard indices
- Estimation of damage distances for the accidental release scenarios with recourse to Maximum Credible Accident (MCA) analysis
- Hazard and Operability studies (HAZOP) in order to identify potential failure cases of significant consequences
- Estimation of probability of occurrences of hazardous event through fault tree analysis and computation of reliability of various control paths
- Assessment of risk on the basis of above evaluation against the risk acceptability criteria relevant to the situation
- Suggest risk mitigation measures based on engineering judgement, reliability and risk analysis approaches
- Delineation / up-gradation of Disaster Management Plan (DMP).
- Safety Reports: with external safety report/ occupational safety report.

The risk assessment (Figure 4-4) report may cover the following in terms of the extent of damage with resource to MCA analysis and delineation of risk mitigations measures with an approach to DMP.

- Hazard identification – identification of hazardous activities, hazardous materials, past accident records, *etc*.
- Hazard quantification – consequence analysis to assess the impacts
- Risk Presentation
- Risk Mitigation Measures
- Disaster Management Plans

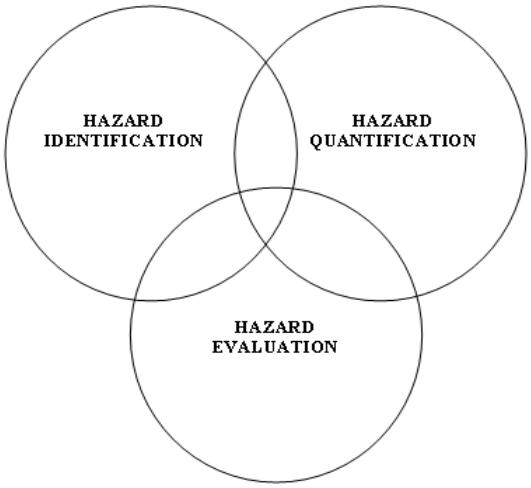


Figure 4-3: Risk Assessment – Conceptual Framework

Predictive methods for estimating risk should cover all the design intentions and operating parameters to quantify risk in terms of probability of occurrence of hazardous events and magnitude of its consequence. Table 4-6 shows the predicted models for risk assessment.

Table 4-4: Guidance for Accidental Risk Assessment

Name	Application	Remarks
EFFECT WHAZAN	▪ Consequence Analysis for Visualization of accidental chemical release scenarios & its consequence ▪ Consequence Analysis for Visualization of accidental chemical release scenarios & its consequence	▪ Heat load, press wave & toxic release exposure neutral gas dispersion
EGADIS	▪ Consequence Analysis for Visualization of accidental chemical release scenarios & its consequence	▪ Dense gas dispersion
HAZOP and Fault Tree Assessment	▪ For estimating top event probability	▪ Failure frequency data is required
Pathways reliability and protective system hazard analysis	▪ For estimating reliability of equipments and protective systems	▪ Markov models
Vulnerability Exposure models	▪ Estimation of population exposure	▪ Uses probit equation for population exposure
F-X and F-N curves	▪ Individual / Societal risks	▪ Graphical Representation

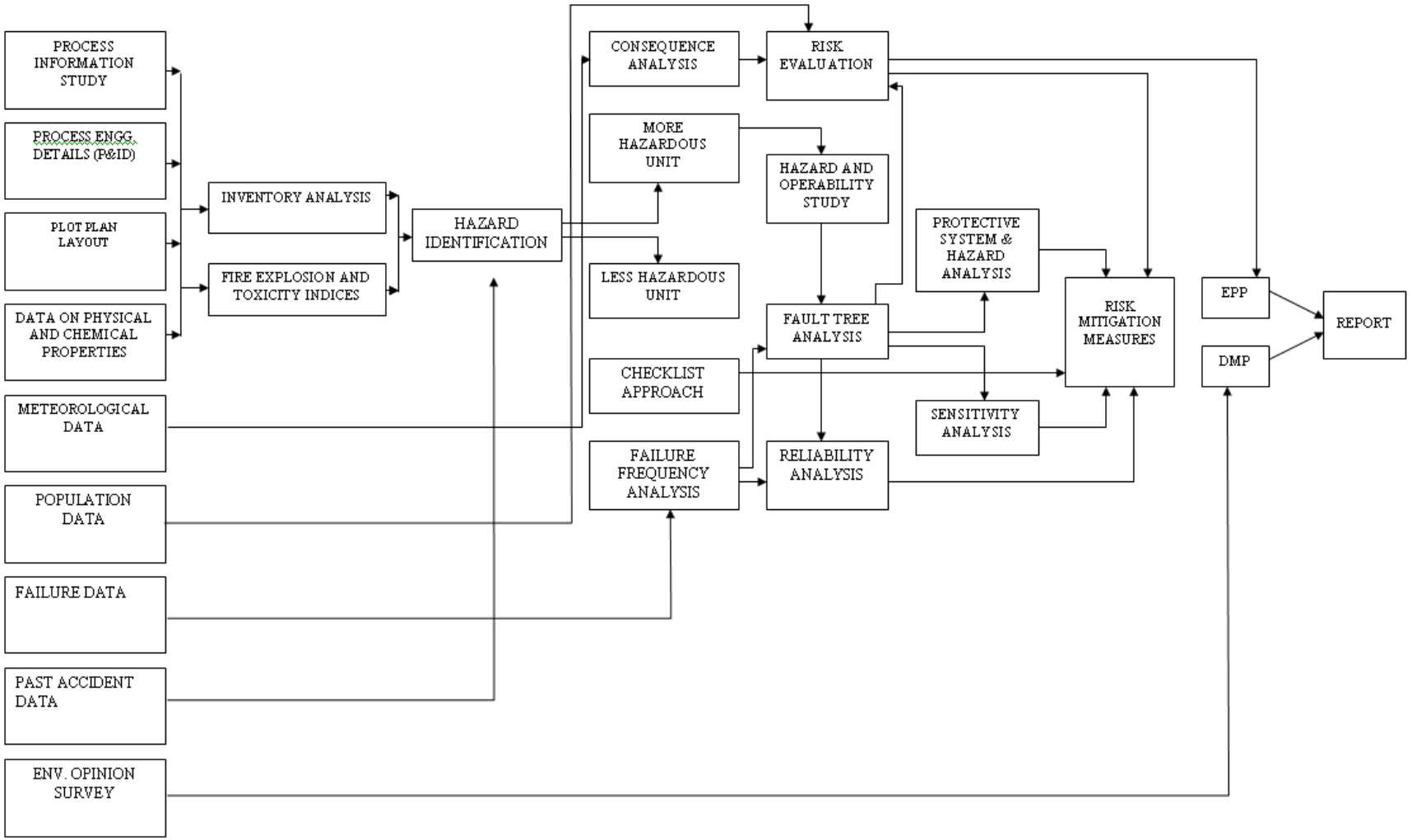


Figure 4-4: Comprehensive Risk Assessment - At a Glance

4.6 Mitigation Measures

The purpose of mitigation is to identify measures that safeguard the environment and the community affected by the proposal. Mitigation is both a creative and practical phase of the EIA process. It seeks to find the best ways and means of avoiding, minimizing and remedying impacts. Mitigation measures must be translated into action in the correct way and at the right time, if they are to be successful. This process is referred to as impact management and takes place during project implementation. A written plan should be prepared for this purpose, and includes a schedule of agreed actions. Opportunities for impact mitigation will occur throughout the project cycle.

4.6.1 Important Considerations for Mitigation Methods

The responsibility of project proponents to 'internalize' the full environmental costs of development proposals is now widely accepted under "Pollutant Pay" principle. In addition, many proponents have found that good design and impact management can result in significant savings applying the principles of cleaner production to improve their environmental performance.

- The predicted adverse environmental as well as social impacts for which mitigation measures are required should be identified and briefly summarized along with cross referencing them to the significance, prediction components of the EIA report or other documentation.
- Each mitigation measure should be briefly described with reference to the impact of significances to which it relates and the conditions under which it is required (for example, continuously or in the event of contingencies). These should also be cross-referenced to the project design and operating procedures which elaborate on the technical aspects of implementing the various measures.
- Cost and responsibilities for mitigation and monitoring should be clearly defined, including arrangements for co-ordination between the various authorities responsible for mitigation.
- The proponent can use the EMP to develop environmental performance standards and requirements for the project site as well as supply chain. An EMP can be implemented through Environment Management Systems (EMS) for the operational phase of the project.

Prior to selecting mitigation plans it is appropriate to study the mitigation alternatives for cost-effectivity, technical and socio-political feasibility. Such Mitigation measures could include:

- avoiding sensitive areas such as eco-sensitive area e.g. fish spawning areas, dense mangrove areas or areas known to contain rare or endangered species
- adjusting work schedules to minimize disturbance
- pollution control devices, such as scrubbers and electrostatic precipitators

4.6.2 Hierarchy of Elements of Mitigation Plan

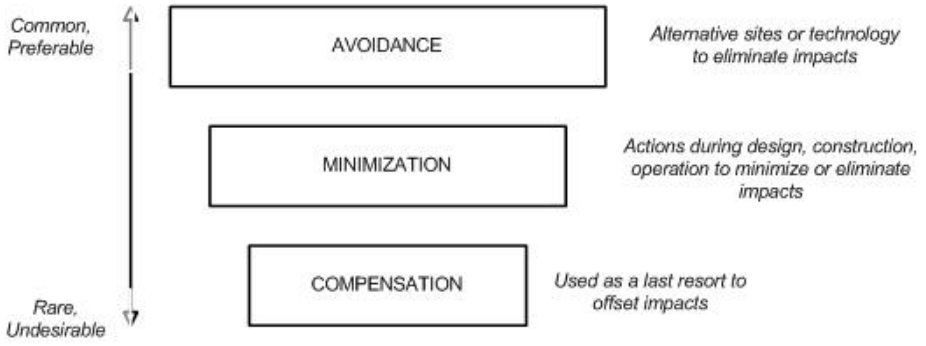


Figure 4-5: Elements of Mitigation

Good EIA practice requires a relevant technical understanding of the issues and the measures that work in the circumstances: The priority of selection of mitigation measures should be in the order:

Step One: Impact Avoidance

This step is most effective when applied at an early stage of project planning. It can be achieved by:

- not undertaking certain projects or elements that could result in adverse impacts
- avoiding areas that are environmentally sensitive; and
- putting in place the preventative measures to stop adverse impacts from occurring, for example, release of water from a reservoir to maintain a fisheries regime.

Step Two: Impact Minimization

This step is usually taken during impact identification and prediction to limit or reduce the degree, extent, magnitude, or duration of adverse impacts. It can be achieved by:

- scaling down or relocating the proposal;
- redesigning elements of the project; and
- taking supplementary measures to manage the impacts.

Step Three: Impact Compensation

This step is usually applied to remedy unavoidable residual adverse impacts. It can be achieved by:

- rehabilitation of the affected site or environment, for example, by habitat enhancement and restocking fish;
- restoration of the affected site or environment to its previous state or better, as typically required for mine sites, forestry roads and seismic lines; and
- replacement of the same resource values at another location, for example, by wetland engineering to provide an equivalent area to that lost to drainage or infill.

Important Compensation Elements

Resettlement Plans: Special considerations apply to mitigation of proposals that displace or disrupt people. Certain types of projects, such as reservoirs and irrigation schemes and public works, are known to cause involuntary resettlement. This is a contentious issue because it involves far more than re-housing people; in addition, income sources and access to common property resources are likely to be lost. Almost certainly, a resettlement plan will be required to ensure that no one is worse off than before, which may not be possible for indigenous people whose culture and lifestyle is tied to a locality. This plan must include the means for those displaced to reconstruct their economies and communities and should include an EIA of the receiving areas. Particular attention should be given to indigenous, minority and vulnerable groups who are at higher risk from resettlement.

In-kind Compensation

When significant or net residual loss or damage to the environment is likely, in kind compensation is appropriate. As noted earlier, environmental rehabilitation, restoration or replacement have become standard practices for many proponents. Now, increasing emphasis is given to a broader range of compensation measures to offset impacts and assure the sustainability of development proposals. These include impact compensation 'trading', such as offsetting CO_2 emissions by planting forests to sequester carbon.

4.6.3 Typical Mitigation Measures

Table 4-5: Mitigation Measures for Construction Phase

Impacts	Mitigation Steps
Erosion	▪ Windscreens, Maintenance, And Installation Of Ground Cover ▪ Installation Of Drainage Ditches ▪ Runoff And Retention Ponds ▪ Minimize Disturbances And Scarification Of The Surface.
Deforestation	▪ Plant Or Create Similar Areas ▪ Initiate A Tree Planning Program In Other Areas ▪ Donate Land To Conservationalist Groups

Table 4-6: Mitigation Measures for Operation Phase

Impacts	Mitigation steps
Dust pollution	▪ Wetting of roadways to reduce traffic dust particles ▪ Installation of windscreens to breakup the wind flow ▪ Burning of refuse on days when meteorological conditions provide for good mixing and dispersion
Noise pollution	▪ Heavy duty muffler systems on heavy equipment ▪ Limit certain activities
Water pollution and issues	▪ Channeling and retention of water to reduce erosion and situation ▪ Collection and treatment of sewage and organic waste ▪ Increased recycling and reuse of water ▪ Use of biodegradable or otherwise readily treatable additives ▪ Cooling ponds, towers and canals to reduce temperatures

Impacts	Mitigation steps
	of cooling water discharge ▪ Neutralization and sedimentation of wastewater ▪ Dewatering of sludges and appropriate disposal of solids ▪ Use deep well injection below potable levels ▪ Construct liners of ponds and solids waste disposal ▪ Dilute water at point of discharge
Chemical discharges and spills	▪ Develop spill prevention plans ▪ Develop traps and containment system and chemically treat discharges on site
Thermal shock to aquatic organisms	▪ Use alternative heat dissipation design ▪ Dilute thermal condition by discharging water into larger receiving water body ▪ Install mechanical diffusers ▪ Cool water onsite in holding pond prior to discharge ▪ Explore opportunities to use waste heat
Biological	▪ Installation of systems to discourage nesting or perching of birds in dangerous environments ▪ Increased employee awareness to sensitive areas
Disruption of traffic	▪ Develop traffic plan that minimizes road use by workers ▪ Upgrade roads and intersections
Worker exposure to dust	▪ Provide dust collector equipment ▪ Maintain dust levels less than 10 mg/m^3 ▪ Monitor for free silica content ▪ Provide dust masks when levels are exceeded
Worker exposure to toxic gases leaking from the boilers	▪ Maintain boilers properly ▪ Monitor concentrations with levels not to exceed ▪ SO_2 – 5 ppm ▪ CO – 5 ppm ▪ NO_2 – 5 ppm
Worker exposure to excessive noise	▪ Maintain noise levels from below 90 dba ▪ Provide ear protection if in excess
Induced secondary development puts increased demand on infrastructure	▪ Provide infrastructure plan and financial support for increased demands ▪ Construct facilities to reduce demands

4.6.4 Mitigation Measures on Special Environmental Issues

A. Strategic Planning and Management Practices

- Developing programmes to reduce overall emissions and waste generation.
- Resolving problems from handling and disposal hazardous substances from member operations by following guidelines
- Operating and handling raw materials and products in a manner that protects the environment and health and safety of employees while conserving natural resources and efficient usage of energy.
- Promoting among employees and individual and collective sense of responsibility for the prevention of the environment and protection of health and safety of individuals.
- Sharing practices, principles and technical assistance with others in similar field.

- Management support for pollution prevention activities through actions, communications, policies and resource commitments.
- Developing and implementing a programme for improving prevention and early detection of impacts and accidents from the site operations.
- Developing an inventory on significant releases to air, water and land along with sources and evaluation of their impacts.
- Periodic review of pollutants and their impacts
- Identifying the pollution prevention options and opportunities and developing approaches for reducing the releases on health and environment.
- Preferences in release reduction include source reduction, recycling and reuse and treatment.

B. Problems at Different Stages of the Process

Exploration

Petroleum which is a mineral and includes natural gas and related substances is non-toxic in nature. This is because it occurs naturally and is compatible with the bio-sphere. As petroleum is derived from fossilized bio-mass, it does not present environmental problems to living beings. However, environmental aspects are crucial to the petroleum industry. Exploration, development, production and abandonment can cause detrimental problems. Pollution of air, water and land challenges have to be overcomed. Considerable progress has been made by the petroleum industry to combat, minimize and eliminate these problems.

Seismic surveys are conducted to obtain multi-dimensional contours of the oil-field. During exploration testing wells are drilled to obtain samples for geochemical analysis.

Production

The following environmental problems are generally faced during drilling:

- Noise in populated areas
- Barite in the drilling mud could contaminate ground water
- Problems caused by Sulphric acid used for well cleaning
- Sacrificial agents like sulfonates could be absorbed by reservoir rocks
- Methane hydrates could be formed in pipelines, if the pressure difference is large
- Cementing agents to avoid the interaction of drilling fluids on rocks
- Damage control additives like NaCl, KCl *etc*.

Recovery

During primary recovery oil is forced out of the reservoir by gaseous components like Methane, Ethane, carbon Dioxide *etc*. Secondary recovery is achieved by injection of water as well as water flooding chemicals. Enhanced oil recovery ensures collection of most o the oil and oil well is ready to be closed after this. Some of the problems are:

- Surfactant flooding

- Polymer flooding
- Fire flooding
- Steam flooding
- Alkaline flooding

Transportation

Transportation of oil can be through the pipelines or tankers in the case of offshore fields. There are problems associated with transportation by pipelines, which are covered in the section dealing with oil pipelines, but considering problems related with ships it needs to account for the major issue of oil spillages which occur at various places like loading and unloading terminals.

Abandonment

When oil wells are closed due to completion of economic life considerable volume of oil still remains in place. All the chemicals not completely consumed still remain in the reservoir. Problems during abandonment are as follows:

- Production of Hydrogen sulfide by sulphate reducers
- Subsurface mitigation of Methane and on surface severe oxidation by air.
- Subsidence of spent oil field and subsequent earth tremors.
- Oxidation of light petroleum to form viscous air

C. Monitoring Scheme

The term monitoring, in case of environmental pollution, has a number of meanings. In the general sense, it means, the repeated measurement of existing norms against reference points. This enables the changes over a period of time to be followed and deviation in level of pollutants known. There is no universally accepted monitoring programme. It is generally accepted that monitoring complies with the requirement of regulatory agencies.

The Hydrocarbon exploration activities do interact with the environment and it becomes necessary to limit the impact on environment and maintain the ecological balance. The drill site effluents contain not only drain water rig wash, drill cuttings, pump lubricants, but also waste from cement operations and drilling fluids. Presence of caustic soda increases sodium level in soil leading to hard solid crust. Soluble salts make water absorption by plants difficult. Barite used in water based mud is a carrier of cadmium & mercury.

In the case of Off-shore blocks the activities involved are geo-physical/geological exploration, drilling of wells, production testing, processing of oil/gas and produced water followed by transportation of oil/gas by pipelines/tankers. The monitoring programme should take into account the operations of the oilfield in totality. The foremost requirement would be to obtain a research vessel for off-shore monitoring. It should have an onboard scientific laboratory using internationally accepted standards. The study should include water samples, sediment and biological materials. The data obtained should be carefully analyzed for the understanding of spatial and temporal variations and compared with the natural background levels in and around the oil field operations. Various sampling stations should be established. Data from sampling stations within 2 km of the installation are considered immediate vicinity, while data from stations located from 2 to 20 km from the installation are considered as reference stations.

Exploratory drilling is undertaken to establish the presence of hydrocarbons as indicated by seismic survey and interpretation of data. Exploratory drilling is temporary and short duration activity and includes site preparation, well foundation, rig building, drilling and eventually restoration of the well site. This activity takes approximately 3-4 months under normal conditions. Drilling rig is used for the well and involves rotation of drill bit, attached to a long string of a drill pipe down the well. Mud is pumped through the drill string, through the drill bit, which returns up the annulus between the drill string and bore. Drill mud is used to cool the drill bit while drilling, remove cuttings from the well, control formation pressures, suspend and release cuttings, seal permeable formations, maintain well-bore stability, minimize reservoir damage, cool and lubricate the bit *etc*. The drill cuttings are separated from the mud in shale shaker and the fluid is re-circulated. If the presence of hydrocarbons is detected during drilling, production testing is normally conducted. The production testing is carried out to ascertain the reserves and economic viability.

D. Safety Issues

Till recently, safety issues in the upstream oil and gas sector were regulated by the Directorate General of Mines Safety in onshore areas under the Oil Mines Regulations, 1984, with no statutory body for regulating safety in the offshore industry. But following the introduction of the Petroleum and Natural Gas (Safety in Offshore Operations) Rules in June, 2008, the Oil Industry Safety Directorate (OISD) has been delegated the responsibility of enforcing safety norms.

E. Environmental Protection Measures

The following Table provides a summary of environmental protection measures that can be applied in each of the principle steps of the exploration and production process. These measures can be implemented to avoid potential environmental effects and interactions.

Table 4-7: Onshore Activities - Environmental Protection Measures

Activity	Source of Potential Impact	Environmental Protection Measures
Aerial survey	**Aircraft**	▪ Environmental assessment shall be carried out to identify the sensitive areas. ▪ Operations shall be properly scheduled during least sensitive periods
Seismic operations (onshore)	**Seismic equipment**	▪ Shot-hole method should be considered in place of vibroseis where preservation of vegetation cover is required and where access is a concern. Ensure charge is small enough and deep enough to avoid cratering. Consider aquifer protection and proper plugging. Use offsets to avoid specify sensitivities. Ensure misfired charges are disabled. Mobilize clean – up crew after operations. ▪ Vibroseis-avoid excessive compaction on soft ground both by access of vehicles and from baseplate. Use adequate noise attenuation on engines. Carry spill clean-up material in case of fuel and hydraulic fluid leaks. Ensure proper storage of fuels.

	Base camps and access	▪ Local authorities and other stakeholders shall be consulted regarding preferred location. ▪ Site is so chosen, to encourage natural rehabilitation by indigenous flora and also by avoiding removal of vegetation and topsoil/preserve topsoil, and seed source for decommissioning. ▪ Select site to minimize effects on environment and local communities/minimize clearing. ▪ Use existing access if available. ▪ Avoid or minimize road construction/minimize clearing and disturbance/minimize footprint, use existing infrastructure. ▪ Use hand cutting techniques/avoid use of heavy machinery e.g. bulldozers/selectively use machinery. ▪ Minimize size of camp/facilities consistent with operational, health and safety requirements. ▪ Take account of topography, natural drainage and site runoff. Ensure adequate and proper drainage. ▪ Ensure proper handling and storage of fuels and hazardous materials (e.g. explosives). ▪ Use helicopters within safety limits where minimization of ground transport is required (e.g. access, clearing etc.) ▪ Construct helipads to minimize disturbance consistent with operational, health and safety requirements. ▪ Block and control access. ▪ Control workforce activities e.g. hunting, interaction with local population. ▪ Minimize waste, control waste disposal (solids, sewerage). ▪ Prepare contingency plans for spillages, fire risk. ▪ Minimize extraneous noise and light sources.
	Line cutting	▪ Hand-cut lines to minimize disturbance. ▪ Minimize width compatible with operational, health and safety requirements. ▪ Do not cut trees of a diameter greater than local regulations permit (or, in the absence of regulations, greater than 20 cm). ▪ Minimize clearing of vegetation. Leave in place smaller vegetation, topsoil, root stock, seeds, and endangered or protected species and species used by local communities for commercial or subsistence use (identified by environmental assessment).
	Decommissioning and restoration	▪ Consult with local authorities and other stakeholders, particularly if any infrastructure is to remain. ▪ Render access routes, campsites, seismic lines inaccessible. ▪ Break-up compacted surfaces/replace topsoil, brash, seed source, leaf litter etc. ▪ Remove non-native materials. ▪ Stabilize all slopes. If necessary re-vegetate to avoid erosion. ▪ Keep photographic record. ▪ Review success of restoration at a later date.

Exploration and appraisal drilling (onshore)	**Site selection**	▪ Use environmental assessment to identify protected areas/sensitivities. Schedule operations during least sensitive periods. ▪ Select least sensitive location within confines of bottom target/drilling envelope. Consider directional drilling to access targets beneath sensitive areas. ▪ Siting to minimize impacts on water resources, conservation interests, settlement, agriculture, sites of historical and archaeological interest and landscape. Consider using site that has been cleared/disturbed previously or of low ecological value, or which may be more easily restore, e.g. agricultural land. ▪ Consult local authorities and other stakeholders regarding preferred location for drilling sites, camps and access/maximize use of existing infrastructure. ▪ Select location to be as unobtrusive as possible, with minimal visual intrusion. ▪ Take account of topography, natural drainage and site run-off. Avoid areas prone to flooding. ▪ Select site close to established good access. ▪ Plan subsequent restoration requirements. ▪ In remote locations, consider best use of transport 'helirigs'/slim-hole drilling/helicopter/water transportation, consistent with operational, health and safety requirements. ▪ Consider cluster drilling to minimize footprint.
	Access	▪ Consult with local authorities regarding preferred routings. ▪ Where possible use existing road/water infrastructure. ▪ Plan routing to minimize subsequent disturbance to natural resources and people. ▪ Limit road width and footprint consistent with operational, health and safety requirements. ▪ Minimize vegetation loss and disturbance. ▪ Limit erosion potential / avoid steep slope and drainage courses/avoid cut and fill techniques/incorporate proper drainage, culverting and bridging techniques. ▪ Road construction should use local material, but minimize cutting of timber. ▪ Block and control access/prevent unauthorized use.

	Site preparation	▪ Minimize cleared area and size of site/maximize perimeter to area ration to aid natural revegetation. ▪ Use hand cutting to clear vegetation initially – where necessary be selective in using machinery. ▪ Conserve root stock and topsoil, store for later rehabilitation. ▪ Limit leveling activity. ▪ Do not burn brush and uprooted materials. ▪ Where vegetation and soil are removed ensure proper separation and storage/collect seed, rootstock, brash for subsequent revegetation. ▪ Incorporate drainage and minimize disturbance to natural drainage patters. Engineer slopes and drainage to minimize erosion. Design for storm conditions. Ensure offsite natural run-off does not wash over site/use perimeter drainage ditches. ▪ Seal bund and ensure proper drainage of machinery area, fuel and chemical storage, and mud mixing areas. ▪ Provide base material compatible with local ground conditions. Hard core should be laid on geotextile membrane. Avoid concreting site. ▪ Protect water courses from contamination and siltation. ▪ Protect groundwater from drill stem penetration and shallow aquifers from possible site contamination. ▪ Where water courses and aquifers are deemed sensitive, consider a fully sealed site, avoid use of mud pits, preferentially use steel tanks, but if used must be lined. Pits if used must be lined. ▪ Mud and burn pits, if used, must have adequate contingency capacity especially in areas of high rainfall, and must be fully lined and bunded.
	Camp and operations	▪ Water supply: - carefully consider water supply sources (ground water, surface or marine). In areas of water shortage consider water separation/recycling package in mud system. If marine sources are used care must be taken with regard to disposal. ▪ Aqueous discharges: - exploration sites rarely incorporate sophisticated effluent treatment systems, therefore treat contaminated water as liquid waste. ▪ Treat surface drainage water in an interceptor with hay filter or similar. ▪ Utilize local sewerage disposal facilities where available. For small, isolated sites, soak away/septic field system can be utilized, biodegradable solids may be buried, liquid discharges should be controlled to ensure that local water resources, both surface and ground water, are not contaminated. ▪ Containerize spent oils and lubes for proper disposal or recycling. ▪ Any produced water from well test operations must be properly disposed of. Ensure disposal options are addressed in planning phase and requirements are met. ▪ Solid wastes: - where approved disposal sites are available and suitable these should be used for all offsite waste disposal. On-site disposal may be considered for inert materials. Ensure proper documentation and manifesting. Ensure adequate consultation with local authorities regarding nature, type and volumes of wastes arising and

		capability and capacity of local resources. ▪ Do not discard litter and debris around sites. All wastes to be containerized on-site. ▪ In isolated/remote areas, with no local disposal facilities, puterscible, not-toxic waste may be buried at a depth of 1m or more during decommissioning. Ensure local water resources are not at risk from contamination. ▪ In isolated/remote areas, with no local disposal facilities, non-toxic dry and liquid wastes may be burnt, giving due consideration to atmospheric effects. If necessary portable incinerators can be used to provide a cleaner burn. ▪ Containerize contaminated soils which cannot be treated *in situ* and remove offsite for treatment. ▪ Consider bulk supply of materials to minimize use of oil (OBM) and synthetic muds to where required for operational reasons. Mud make-up and mud and cuttings disposal options must be addressed during planning phase, ensure all requirements are met. Consider downhole disposal of OBM wastes otherwise treat as hazardous waste. ▪ Requirements of oil spill and emergency plans must be met before operations commence. ▪ Hazardous materials usage, storage and disposal requirements must meet planning requirements. ▪ Atmospheric emission/noise/light: - Ensure requirements from planning phase are met to minimize effects from engine exhausts and extraneous noise and light. Ensure any H_2S problems are addressed. Ensure well test procedures are followed. Any burn pits utilized for well test operations must be line. If possible produced oil should be stored for subsequent use. ▪ Noise levels at the site boundary should meet local or company specified. Ensure all machinery and equipment are properly cladded. ▪ Light sources should be properly shaded and directed onto site area. ▪ Socio-economic/cultural. Ensure all requirements addressed in planning phase are fully met. ▪ Initiate consultation and liaison with local authorities. Use local expertise. ▪ Workforce should keep within defined boundary and to the agreed access routes. ▪ Control workforce activities, e.g. hunting, interaction with local population. Purchase food from recognized local suppliers, not directly from local people without evaluating implications.
	Decommissioning and restoration	▪ Restoration plan must be followed and site restored to its original condition. ▪ Remove all debris and contaminated soils. ▪ Reform contours to natural surroundings. ▪ Restore natural drainage patterns. ▪ Break-up base material/re-spread topsoil and brash, vegetation, leaf litter and organic material. Use specialized techniques where sensitivities dictate, e.g. brushwood barriers, seeding, turf, etc., ▪ Mud pits, where used, should be de-watered and filled in to 1m cover. In fill burn and wasted pits to 1m. ▪ Block access routes, or if required, hand over to local

		authorities. ▪ Document and monitor site recovery.
Development and production (onshore)	**Access**	▪ Requirement for permanent long-term access routes - appropriate design and engineering considerations required, in particular consideration of long-term disturbance from vehicle traffic volume and density in terms of environmental infrastructure and local population. ▪ All aspects identified for exploration drilling should be applied to permanent access routes. ▪ Consultation with local authorities is required.
	Site preparation	▪ Long-term occupation of sites and permanent structures and infrastructure-appropriate design and engineering considerations required, in particular consideration of long-term disturbance and effect on environment, infrastructure and local population. ▪ All aspects identified for exploration drilling should be applied to permanent sites. ▪ Consultation with local authorities is required. ▪ Site selection procedures must avoid long-term disturbance and impact on local environment and infrastructure. ▪ Consider locating all facilities at single site to minimize footprint. ▪ Consider maximizing use of satellite/cluster drilling sites, horizontal wells, and extended reach drilling in sensitive areas. ▪ Use consolidated, impermeable base to all facilities with permanent inbuilt drainage systems. ▪ Segregate drainage systems for offsite and non-contaminated/ clean site areas and oily drainage system for process areas. ▪ Consider construction and drilling activities and impacts separately from operational activities. Construction and drilling will utilize intensive methods and will be longer term compared to exploration construction and drilling requirements. ▪ Flowlines and pipeline routing will require consideration in terms of disturbance and effects (bury/surface). ▪ Site selection and preparation planning should include consideration of eventual decommissioning and restoration.
	Operations	▪ Assess implications of well treatment and workover, process, storage, power generation and other support and accommodation facilities in terms of long-term disturbance and impact. ▪ Assess implications of development on local infrastructure in particular water supply, power supply, waste disposal and socioeconomic considerations-housing, education, welfare, medical, employment/economy etc. ▪ Install proper waste treatment facilities, particularly if local infrastructure cannot support requirements. In particular, treatment of waste waters-wash water, process water, drainage, sewage, produced water. Reinjection of produced water is a preferred option. ▪ Assess treatment of waste gases and emission limits, particularly where gas flaring is necessary. Avoid gas venting ▪ Solid wastes, particularly toxic and hazardous substances, will require full assessment in terms of treatment and

		disposal options. If local facilities unavailable, proper incineration facilities may be required and a full assessment of implications will be necessary. ▪ Prepare a detailed waste management plan. ▪ Install oil sumps, interceptors and oily water treatment system. ▪ Provide contained storage areas for produced oil, chemicals and hazardous materials, including treatment of tank sludges. ▪ Prepare detailed contingency plans, personnel training and regular exercise of response. ▪ Establish consultation and local liaison activities. ▪ Monitor waste streams in order to meet compliance requirements.
	Decommissioning and aftercare	▪ Develop full decommissioning, restoration and aftercare plan in consultation with local authorities. ▪ Hand over any facilities and infrastructure to local authorities with proper instructions for use, maintenance and include proper training procedures. ▪ Remove, if appropriate, all permanent structures, foundations and bases, roads etc. ▪ Restore the site to its original condition, leveled and contoured for drainage and erosion control and prepared for revegetation. ▪ If replanting is undertaken, select indigenous species compatible with the surrounding habitat. ▪ Successful reinstatement will require proper planning and implementation and should not be viewed as an afterthought or a short-term commitment. ▪ Record and monitor site recovery.

Table 4-8: Offshore – Environmental Protection Measures

Activity	Source of Potential Impacts	Environmental Protection Measures
Seismic operations (offshore)	Seismic equipment	▪ Use environmental assessment to identify protected and local sensitivities. Schedule operations during least sensitive period.
	Vessel operations	▪ Consult local authorities and other stakeholder regarding survey programme, permitting and notifications. ▪ Remain on planned survey track to avoid unwanted interaction. ▪ Dispose all waste materials and oily water properly to meet local, national and international regulations (Refer to MARPOL). ▪ Apply proper procedures for handling and maintenance of cable equipment particularly cable oil. ▪ All towed equipment must be highly visible. ▪ Make adequate allowance for deviation of towed equipment when turning. ▪ Prepare contingency plans for lost equipment and oil spillage. ▪ Attach active acoustic location devices to auxiliary equipment to aid location and recovery.

		▪ Label all towed equipment. ▪ Store and handle explosives according to operators procedures and local regulations. ▪ Consider using guard boat in busy areas. ▪ Report all unplanned interactions with other resource users or marine life to the authorities. ▪ Use local expertise to support operations e.g. spotting marine mammals, wildlife etc.
Exploration and appraisal drilling (offshore)	Site selection	▪ Use environmental assessment to identify protected areas and sensitivities. Schedule operations during least sensitive periods. ▪ Consult with local authorities regarding site selection and support infrastructure-ports, vessel and air traffic. ▪ Select least sensitive location within confines of bottom target/drilling envelope. Consider directional drilling to access targets beneath sensitive areas. Consider cluster well drilling. ▪ Local conditions must be fully assessed-wave, wind and currents. ▪ In coastal areas, select site and equipment to minimize disturbance, noise, light and visual intrusion.
	Access	▪ Exercise strict control on access and all vessel and rig activity. ▪ In coastal areas where sensitivities dictate use vessels in preference to helicopters.
	Operations	▪ Consult with local authorities regarding emissions, discharges and solid waste disposal/notifications in regard to other resource users. ▪ Requirements specified in planning process must be met including supply vessel operations. ▪ Aqueous discharges. Oily water from deck washing, drainage systems, bilges etc. should be treated prior to discharge to meet local, national and international consents. ▪ Sewerage must be properly treated prior to discharge to meet local and international standards. Treatment must be adequate to prevent discoloration and visible floating matter. ▪ Biodegradable kitchen wastes require grinding prior to discharge, if permitted under local regulations. ▪ Most spills and leakage occur during transfer operations - ensure adequate preventative measures are taken and that spill contingency plan requirements are in place. ▪ Store oils and chemicals properly in contained, drained areas. Limit quantities stored to a minimum level required for operational purposes. Ensure proper control documentation and manifesting and disposal. Do not dispose of waste chemicals overboard. ▪ Produced water from well tests must meet local regulations or company specified standards prior to discharge. ▪ Preferentially separate and store oil from well test operations. If burnt, ensure burner efficiency is adequate to prevent oil fallout onto sea surface. ▪ Solid wastes. Ensure requirements specified in the planning process are met with regard to waste treatment and disposal. ▪ Collect all domestic waste and compact for onshore disposal. Ensure proper documentation and manifesting.

		Ensure onshore receiving and disposal meet local requirements. ▪ Consider waste segregation at source for different waste types-organic, inorganic industrial wastes etc. ▪ No debris or waste to be discarded overboard from rig or supply vessels. ▪ Waste containers must be closed to prevent loss overboard. ▪ Spent oils and lubes should be containerized and returned to shore. ▪ Consider bulk supply of materials to minimize packaging wastes. ▪ Muds and cuttings. Preferentially use low toxicity water-based drilling muds. Minimize use of oil-based muds (OBM). ▪ Mud make-up and mud and cuttings disposal requirements addressed in the planning process must be met. ▪ Do not dispose of whole OBM to sea. Any oily cuttings discharged must meet local regulations or company specified standards. ▪ Consider downhole disposal of OBM wastes. ▪ Atmospheric emission/noise/light. Ensure requirements addressed in the planning phase are met with regard to emissions, noise and light. ▪ Well test burners must be efficient, maintained and effectively burn gas and oil. ▪ H2S emissions must be effectively controlled.
	Decommissioning and restoration	▪ All debris must be removed from seabed. ▪ Decommissioning of onshore support facilities must meet planning requirements.
Development and production (offshore)	Site selection and access	▪ Long-term occupation of sites, including supply and support base, will require detailed assessment of environmental implications, particularly where resource use conflicts arise and commercially important species may be affected. ▪ All aspects identified for exploration drilling should be applied to permanent sites. ▪ Consult with local authorities. ▪ Consider site and route selection for flowlines and pipelines.
	Operations	▪ Evaluate construction and drilling activities and impacts separately from operational activities. ▪ Maximize use of central processing facility and use of satellite and cluster wells to minimize footprint. ▪ All aspects identified for exploration drilling should be applied to permanent sites. ▪ Consult with local authorities. ▪ Assess full implications of well treatment and workover, process, storage, power generation and other support and accommodation facilities in terms of long-term disturbance and impact. ▪ Evaluate implications of development on local infrastructure, in particular, infrastructure related to onshore service functions-port and harbour operations, resource use conflicts, waste treatment and disposal, socio-economic implications, employment, local services and supply, support infrastructure for employee and family accommodation ete.

		▪ Incorporate oily water treatment system for both produced water and contaminated water treatment to meet local, national and international discharge limits. ▪ Include sewerage treatment system, particularly if close to shore, to meet local requirements. ▪ Assess treatment of waste gases and emission limits, particularly where gas is flared. Avoid gas venting. ▪ Treatment and disposal of solid, toxic and hazardous wastes onshore will require proper planning, particularly if local infrastructure is limited in capacity and capability. A detailed waste management plan will be required. ▪ Prepare detailed contingency plans, personnel training and regular exercise of response, taking into consideration storage and export systems. ▪ Establish consultation and local liaison activities. ▪ Monitor waste streams in order to meet compliance requirements.
	Decommissioning and rehabilitation	▪ Develop a full decommissioning and rehabilitation plan in consultation with local authorities. ▪ Any facilities and infrastructure handed over to local authorities must include proper instructions for use, maintenance and include proper training procedures. ▪ Decommissioning of offshore structures is subject to international and national laws, and should be dealt with on a case by ease basis with local authorities. ▪ Record and monitor site as required after appropriate decommissioning activities.

4.7 Environmental Management Plan

A typical EMP shall be composed of the following:

1. summary of the potential impacts of the proposal ;
2. description of the recommended mitigation measures ;
3. statement of their compliance with relevant standards ;
4. allocation of resources and responsibilities for plan implementation ;
5. schedule of the actions to be taken ;
6. programme for surveillance, monitoring and auditing ; and
7. contingency plan when impacts are greater than expected

Each of the above components are precisely discussed below:

Summary of impacts: The predicted adverse environmental and social impacts for which mitigation measures are identified in the earlier sections to be briefly summarized with cross referencing to the corresponding sections in the EIA report.

Description of mitigation measures: Each mitigation measure should be briefly described with reference to the impact to which it relates and the conditions under which it is required. These should be accompanied by, or referenced to, project design and operating procedures which elaborate on the technical aspects of implementing the various measures.

Description of monitoring programme: Environmental monitoring refers to compliance monitoring and residual impact monitoring. Compliance monitoring refers to meeting the industry-specific statutory compliance requirements (Ref. Applicable National regulations as detailed in Chapter 3).

Residual impact monitoring refers to monitoring of identified sensitive locations with adequate number of samples and frequency. The monitoring programme should clearly indicate the linkages between impacts identified in the EIA report, measurement indicators, detection limits (where appropriate), and definition of thresholds that will signal the need for corrective actions.

Institutional arrangements: Responsibilities for mitigation and monitoring should be clearly defined, including arrangements for co-ordination between the various actors responsible for mitigation. Details should be provided w.r.t the deployment of staff (detailed organogram), monitoring network design, parameters to be monitored, analysis methods, associated equipments *etc.*

Implementation schedule and reporting procedures: The timing, frequency and duration of mitigation measure should be specified in an implementation schedule, showing links with overall project implementation. Procedures to provide information on the progress and results of mitigation and monitoring measures should also be clearly specified.

Cost estimates and sources of funds: These should be specified for both the initial investment and recurring expenses for implementing all measures contained in the EMP, integrated into the total project costs, and factored into loan negotiation.

The EMP should contain commitments that are binding on the proponent in different phases of project implementation *i.e.* pre-construction or site clearance, construction, operation, decommissioning.

4.8 Reporting

Structure of the EIA report is given in the Table 4.7. Each task prescribed in ToR shall be incorporated appropriately in the contents in addition to the described in the table.

Table 4-9: Structure of EIA Report

S.NO	EIA STRUCTURE	CONTENTS
1.	Introduction	▪ Purpose of the report ▪ Identification of project & project proponent ▪ Brief description of nature, size, location of the project and its importance to the country, region ▪ Scope of the study – details of regulatory scoping carried out (As per the ToR for EIA studies)
2.	Project Description	▪ Condensed description of those aspects of the project (based on project feasibility study), likely to cause environmental effects. Details should be provided to give clear picture of the following: ▪ Type of project ▪ Need for the project ▪ Location (maps showing general location, specific location, project boundary & project site layout) ▪ Size or magnitude of operation (incl. Associated activities required by or for the project) ▪ Proposed schedule for approval and implementation ▪ Technology and process description ▪ Project description including drawings showing project layout, components of project *etc*. Schematic representations of the feasibility drawings which give information important for EIA purpose ▪ Description of mitigation measures incorporated into the project to meet environmental standards, environmental operating conditions, or other EIA requirements (as required by the scope) ▪ Assessment of New & untested technology for the risk of technological failure
3.	Description of the Environment	▪ Study area, period, components & methodology ▪ Establishment of baseline for VECs as identified in the scope ▪ Base maps of all environmental components
4.	Anticipated Environmental Impacts & Mitigation Measures	▪ Details of Investigated Environmental impacts due to project location, possible accidents, project design, project construction, regular operations, final decommissioning or rehabilitation of a completed project ▪ Measures for minimizing and / or offsetting adverse impacts identified ▪ Irreversible and Irretrievable commitments of environmental components ▪ Assessment of significance of impacts (Criteria for

		determining significance, Assigning significance) ▪ Mitigation measures
5.	Analysis of Alternatives (Technology & Site)	▪ Incase, the scoping exercise results in need for alternatives: ▪ Description of each alternative ▪ Summary of adverse impacts of each alternative ▪ Mitigation measures proposed for each alternative and selection of alternative
6.	Environmental Monitoring Program	▪ Technical aspects of monitoring the effectiveness of mitigation measures (incl. Measurement methodologies, frequency, location, data analysis, reporting schedules, emergency procedures, detailed budget & procurement schedules)
7.	Additional Studies	▪ Public Consultation ▪ Risk assessment ▪ Social Impact Assessment, R&R Action Plans
8.	Project Benefits	▪ Improvements in the physical infrastructure ▪ Improvements in the social infrastructure ▪ Employment potential –skilled; semi-skilled and unskilled ▪ Other tangible benefits
9.	Environmental Cost Benefit Analysis	▪ If recommended at the Scoping stage
10.	EMP	▪ Description of the administrative aspects of ensuring that the measures of mitigation are implemented and their effectiveness monitored, after approval of the EIA
11.	Summary & Conclusion (This will constitute the summary of the EIA Report)	▪ Overall justification for implementation of the project ▪ Explanation of how, adverse effects have been mitigated
12.	Disclosure of Consultants engaged	▪ The names of the Consultants engaged with their brief resume and nature of Consultancy rendered

4.9 Public Consultation

Public consultation refers to the process by which the concerns of local affected people and others who have plausible stake in the environmental impacts of the project or activity are ascertained.

- Public consultation is not a decision taking process, but is a process to collect views of the people having plausible stake. If the SPCB/Public agency conducting public hearing is not convinced with the plausible stake, then such expressed views need not be considered.
- Public consultation involves two components, one is public hearing, and other one is inviting written responses/objections through Internet/by post, *etc.*, by placing the summary of EIA report on the web site.
- In case of offshore oil and gas exploration, production and development beyond 10 km from village boundaries, goathans and ecologically sensitive areas such as marine national parks, sanctuaries, etc. may be exempted from the physical public hearing

but public consultation shall be applicable in the form of displaying their documents in websites, seek responses and giving clarification/revisions as decided by the EAC.

- Public consultation involves two components, one is public hearing, and other one is inviting written responses/objections through Internet/by post, *etc*., by placing the summary of EIA report on the web site.
- Public hearing shall be carried out at the site or in its close proximity, district-wise, for ascertaining concerns of local affected people.
- Project proponent shall make a request through a simple letter to the Member–Secretary of the SPCB or UTPCC to arrange public hearing.
- Project proponent shall enclose with the letter of request, at least 10 hard copies and 10 soft copies of the draft EIA report including the summary EIA report in English and local language prepared as per the approved scope of work, to the concerned Authority.
- Simultaneously, project proponent shall arrange to send, one hard copy and one soft copy, of the above draft EIA report along with the summary EIA report to the following Authorities within whose jurisdiction the project will be located:
  - District magistrate(s)
  - Zilla parishad and municipal corporation
  - District industries office
  - Concerned regional office of the MoEF/SPCB
- Above mentioned Authorities shall arrange to widely publicize the draft EIA report within their respective jurisdictions. They shall also make draft EIA report for inspection electronically or otherwise to the public during normal hours till the public hearing is over.
- Concerned regulatory Authority (MoEF) shall display the summary of EIA report on its website and also make full draft EIA report available for reference at a notified place during normal office hours at their head office.
- SPCB or UTPCC concerned shall make arrangements for giving publicity about the project within the State/UT and make available the summary of draft EIA report for inspection in select offices, public libraries. They shall also additionally make available a copy of the draft EIA report to the above five authorities/offices as mentioned.
- The Member–Secretary of the concerned SPCB or UTPCC shall finalize the date, time and exact venue for the conduct of public hearing within seven days of the date of the receipt of the draft EIA report from the project proponent and advertise the same in one major National Daily and one Regional vernacular Daily.
- A minimum notice period of 30 (thirty) days shall be provided to the public for furnishing their responses.
- No postponement of the date, time, venue of the public hearing shall be undertaken, unless some untoward emergency situation occurs and only then on the recommendation of the concerned District Magistrate the postponement shall be notified to the public through the same National and Regional vernacular dailies and also prominently displayed at all the identified offices by the concerned SPCB or UTPCC.
- In the above exceptional circumstances fresh date, time and venue for the public consultation shall be decided by the Member–Secretary of the concerned SPCB or

UTPCC only in consultation with the District Magistrate and notified afresh as per the procedure.

- The District Magistrate or his or her representative not below the rank of an Additional District Magistrate assisted by a representative of SPCB or UTPCC, shall supervise and preside over the entire public hearing process.
- The SPCB or UTPCC shall arrange to video film the entire proceedings. A copy of the videotape or a CD shall be enclosed with the public hearing proceedings while forwarding it to the Regulatory Authority concerned.
- The attendance of all those who are present at the venue shall be noted and annexed with the final proceedings
- There shall be *no quorum* required for attendance for starting the proceedings
- Every person present at the venue shall be granted the opportunity to seek information or clarifications on the project from the Applicant. The summary of the public hearing proceedings accurately reflecting all the views and concerns expressed shall be recorded by the representative of the SPCB or UTPCC and read over to the audience at the end of the proceedings explaining the contents in the vernacular language and the agreed minutes shall be signed by the District Magistrate or his or her representative on the same day and forwarded to the SPCB/UTPCC concerned.
- A statement of the issues raised by the public and the comments of the proponent shall also be prepared in the local language and in English and annexed to the proceedings.
- The proceedings of the public hearing shall be conspicuously displayed at the office of the Panchayats within whose jurisdiction the project is located, office of the concerned Zilla Parishad, District Magistrate, and the SPCB or UTPCC. The SPCB or UTPCC shall also display the proceedings on its website for general information. Comments, if any, on the proceedings, may be sent directly to the concerned regulatory authorities and the Applicant concerned.
- The public hearing shall be completed within a period of 45 (forty five) days from date of receipt of the request letter from the Applicant. Therefore the SPCB or UTPCC concerned shall send the public hearing proceedings to the concerned regulatory authority within 8(eight) days of the completion of the public hearing. The proponent may also directly forward a copy of the approved public hearing proceedings to the regulatory authority concerned along with the final EIA report or supplementary report to the draft EIA report prepared after the public hearing and public consultations.
- Upon receipt of the same, the Authority will place executive summary of the report on the website to invite responses from other concerned persons having a plausible stake in the environmental aspects of the project or activity.
- If SPCB/UTPCC is unable to conduct the public hearing in the prescribed time, the Central Government at the request of the project proponent can engage a public agency for conducting the public hearing process within a further period of 45 days. The respective governments shall pay the appropriate fee to the public agency for conducting public hearing.
- A public agency means a non-profit making institution/ body such as technical/academic institutions, government bodies not subordinate to the concerned Authority.

- If SPCB/Public Agency authorized for conducting public hearing informs the Authority, stating that it is not possible to conduct the public hearing in a manner, which will enable the views of the concerned local persons to be freely expressed, then Authority may consider such report to take a decision that in such particular case, public consultation may not have the component of public hearing.
- Often restricting the public hearing to the specific district may not serve the entire purpose, therefore, NGOs who are local and registered under the Societies Act in the adjacent districts may also be allowed to participate in public hearing, if they so desire.
- Confidential information including non-disclosable or legally privileged information involving intellectual property right, source specified in the application shall not be placed on the website.
- The Authority shall make available on a written request from any concerned person the draft EIA report for inspection at a notified place during normal office hours till the date of the public hearing.
- While mandatory requirements will have to be adhered to, utmost attention shall be given to the issues raised in the public hearing for determining the modifications needed in the project proposal and the EMP to address such issues.
- Final EIA report after making needed amendments, as aforesaid, shall be submitted by the applicant to the concerned Authority for prior environmental clearance. Alternatively, a supplementary report to draft EIA and EMP addressing all concerns expressed during the public consultation may be submitted.

4.10 Appraisal

Appraisal means the detailed scrutiny by the EAC of the application and the other documents like the final EIA report, outcome of the public consultation including public hearing proceedings submitted by the applicant for grant of environmental clearance.

- The appraisal shall be made by EAC concerned to the Central Government.
- Project proponent either personally or through consultant can make a presentation to the EAC for the purpose of appraising the features of the project proposal and also to clarify the issues raised by the members of the EAC.
- On completion of these proceedings EAC shall make categorical recommendations to the respective Authority, either for grant of prior environmental clearance on stipulated terms & conditions, if any, or rejection of the application with reasons.
- In case EAC needs to visit the site or obtain further information before being able to make categorical recommendations, EAC may inform the project proponent accordingly. In such an event, it should be ensured that the process of environmental clearance is not unduly delayed to go beyond the prescribed timeframe.
- Upon the scrutiny of the final report, if EAC opines that ToR finalized at the scoping stage has not been covered by the proponent, then the project proponent may be asked to provide such information. If such information is declined by the project proponent or is unlikely to be provided early enough so as to complete the environmental appraisal within prescribed time of 60 days, the EAC may recommend for rejection of the proposal with the same reason.
- Appraisal shall be strictly in terms of the ToR finalized at the scoping stage and the concerns expressed during public consultation.

- This process of appraisal shall be completed within 60 days from the receipt of the updated EIA report and EMP report, after completing public consultation.
- The EIA report will be typically examined for following:
  - Project site description supported by topographic maps & photographs – detailed description of topography, land use and activities at the proposed project site and its surroundings (buffer zone) supported by photographic evidence.
  - Clarity in description of drainage pattern, location of eco sensitive areas, vegetation characteristics, wildlife status - highlighting significant environmental attributes such as feeding, breeding and nesting grounds of wildlife species, migratory corridor, wetland, erosion and neighboring issues.
  - Description of the project site – how well the interfaces between the project related activities and the environment have been identified for the entire project cycle *i.e.* construction, operation and decommissioning at the end of the project life.
  - How complete and authentic are the baseline data pertaining to flora and fauna and socio economic aspects?
  - Citing of proper references, with regard to the source(s) of baseline data as well as the name of the investigators/ investigating agency responsible for collecting the primary data.
  - How consistent are the various values of environmental parameters w.r.t. each other?
  - Is a reasonable assessment of the environmental and social impact made for the identified environmental issues including project affected people?
  - To what extent the proposed environmental plan will mitigate the environmental impact and at what estimated cost, shown separately for construction, operation and closure stages and also separately in terms of capital and recurring expenses along with details of agencies that will be responsible for the implementation of environmental plan/ conservation plan.
  - How well the concerns expressed/highlighted during the Public hearing have been addressed and incorporated in the EMP giving item wise financial provisions and commitments (in quantified terms)?
  - How far the proposed environmental monitoring plan will effectively evaluate the performance of the EMP? Are details for environmental monitoring plan provided in the same manner as the EMP?
  - Identification of hazard and quantification of risk assessment and whether appropriate mitigation plan has been included in the EMP?
  - Does the proposal include a well formulated time bound green belt development plan for mitigating environmental problems such as fugitive emission of dust, gaseous pollutants, noise, odour *etc*.
  - Does EIA makes a serious attempt to guide the project proponent for minimizing the requirement of natural resources including land, water energy and other non renewable resources?
  - How well the EIA statement has been organized and presented so that the issues, their impact and environmental management strategies emerge clearly from it and how well organized was the power point presentation made before the Expert Committee?

- Is the information presented in the EIA adequately and appropriately supported by maps, imageries and photographs highlighting site features and environmental attributes?

4.11 Decision-making

The Chairperson reads the sense of the Committee and finalizes the draft minutes of the meeting, which are circulated by the Secretary to all the core members and sectoral experts invited to the meeting. Based on the response from the members, the minutes are finalized and signed by the Chairperson. This process for finalization of the minutes should be so organized that the time prescribed for various stages is not exceeded.

Approval / Rejection / Reconsideration

The Authority shall consider the recommendations of concerned appraisal Committee and convey its decision within 45 days of the receipt of recommendations.

- If the Authority disagrees with the recommendations of the Appraisal Committee, then reasons shall be communicated to concerned Appraisal Committee and applicant with in 45 days from the receipt of the recommendations. The Appraisal Committee concerned shall consider the observations of the Authority and furnish its views on the observations within further period of 60 days. The Authority shall take a decision with in the next 30 days based on the views of appraisal Committee.
- If the decision of the Authority is not conveyed within the time, then the proponent may proceed as if the environmental clearance sought has been granted or denied by the regulatory authority in terms of the final recommendation of the concerned appraisal Committee. For this purpose, the decision of the Appraisal Committee will be public document, once the period specified above for taking the decision by the Authority is over.
- Incase of the Category B projects, application shall be received by the Member–Secretary of the SEIAA and clearance shall also be issued by the same SEIAA.

If Approved

- The MoEF will issue an Environmental Clearance for the project.
- The project proponent should make sure that the award of Environmental Clearance is properly publicized in at least two local newspapers of the district or state where the proposed project is located. For instance, the executive summary of the Environmental Clearance may be published in the newspaper along with the information about the location (website/office where it is displayed for public) where the detailed Environmental Clearance is made available. The MoEF shall also place the environmental clearance in the public domain on Government Portal. Further copies of the environmental clearance shall be endorsed to the Heads of local bodies, Panchayats and Municipal bodies in addition to the relevant offices of the Government.
- The Environmental Clearance will be valid from the start date to actual commencement of the production of the developmental activity.

4.12 Post Clearance Monitoring Protocol

The MoEF, Government of India will monitor and take appropriate action under the EP Act, 1986.

The project proponent must submit half-yearly compliance reports in respect of the stipulated prior environmental clearance terms and conditions in hard and soft copies to the regulatory authority concerned, on 1st June and 1st December of each calendar year.

All such compliance reports submitted by the project management shall be public documents. Copies of the same shall be given to any person on application to the concerned regulatory authority. The latest such compliance report shall also be displayed on the web site of the concerned regulatory authority.

The State Pollution Control Board shall incorporate EIA clearance conditions into consent conditions in respect of Category A and Category B projects and in parallel monitor and enforce the same.

5. STAKEHOLDERS' ROLES AND RESPONSIBILITIES

Prior environmental clearance process involves many stakeholders *i.e.,* Central Government, State Government, EAC, Public Agency, SPCB, the project proponents and the public.

- The roles and responsibilities of the organizations involved in different stages of prior environmental clearance are given in Table 5-1.
- Organization-specific functions are listed in Table 5-2.

In this Chapter, constitution, composition, functions, *etc*., of the Authorities and the Committees are discussed in detail.

Table 5-1: Roles and Responsibilities of Stakeholders Involved in Prior Environmental Clearance

Stage	MoEF	EAC	Project Proponent	EIA Consultant	SPCB/ Public Agency	Public and Interest Group
Screening	Receives application and takes advise of EAC	Advises the MoEF	Submits application (Form 1) and provide necessary information	Advises and assists the proponent by providing technical information		
Scoping	Approves the ToR and communicates the same to the project proponent and places the same in the web-site	Reviews ToR and visits the proposed site, if required and recommends the ToR to the MoEF	Submits the draft ToR to EAC and facilitates the visit of the sub-committee members to the project site	Prepares ToR		
EIA Report & Public Hearing	Reviews and forwards copies of the EIA report to SPCB /public agency for conducting public hearing Places the summary of EIA report in the web-site		Submits detailed EIA report as per the finalized ToR Facilitates the public hearing by arranging presentation on the project, EIA and EMP – takes note of objections and	Prepares the EIA report Presents and appraises the likely impacts and pollution control measures proposed in the public hearing	Reviews EIA report and conducts public hearing in the manner prescribed Submits proceedings and views of SPCB, as well, to the	Participates in public hearings and offers comments and observations. Comments can be sent directly to MoEF through

Stage	MoEF	EAC	Project Proponent	EIA Consultant	SPCB/ Public Agency	Public and Interest Group
	Conveys objections to the project proponent for update, if any		updates the EMP accordingly		Authority and the project proponent as well	Internet in response to the summary placed in the website
Appraisal and Clearance	Receives updated EIA Takes advise of EAC, and takes decision (Clearance with required conditions or re-examination/rejection	Critically examines the reports, presentation of the proponent and appraises MoEF (recommendations are forwarded to MoEF)	Submits up-dated EIA, EMP reports to MoEF. Presents the overall EIA and EMP including public concerns to EAC	Provides technical advise to the project proponent and if necessary presents the proposed measures for mitigation of likely impacts (terms and conditions of clearance)		
Post Clearance Monitoring			Implements environmental protection measures prescribed and submits periodic monitoring results	Conducts periodic monitoring	Incorporates the clearance conditions into appropriate consent conditions and ensures implementation	

Table 5-2: Organization-specific Functions

Organization	Functions
Central Government	▪ Constitutes the EAC ▪ Receives application from the project proponent ▪ Communicates the ToR finalized by the EAC to the project proponent ▪ Receives EIA report from the project proponent and soft copy of summary of the report for placing in the website ▪ Summary of EIA report will be placed in website. Forwards the received responses to the project proponent ▪ Engages other public agency for conducting public hearing in case where the SPCB does not respond within time ▪ Receives updated EIA report from project proponent incorporating the considerations from the proceedings of public hearing and responses received through other media ▪ Forwards updated EIA report to the EAC for appraisal ▪ Either accepts the recommendations of EAC or asks for reconsideration of specific issues for review by the EAC. ▪ Takes the final decision – acceptance/rejection of the project proposal and communicates

Organization	Functions
	the same to the project proponent
EAC	▪ Reviews Form 1 and its attachments ▪ Visits site(s), if necessary ▪ Finalizes ToR and recommend to the Central Government, which in turn communicates the finalized ToR to the project proponent if not exempted by the Notification ▪ Reviews EIA report, proceedings and appraises their views to the Central government ▪ If the Central Government has any specific views, then the EAC reviews again for appraisal
SPCB	▪ Receives request from project proponent and conducts public hearing in the manner prescribed. ▪ Conveys proceedings to MoEF and project proponent
Public Agency	▪ Receives request from the respective Governments to conduct public hearing ▪ Conducts public hearing in the manner prescribed. ▪ Conveys proceedings to the MoEF and the Project proponent

5.1 EAC

EAC is an independent Committee to review each developmental activity and offer its recommendations for consideration of the Central Government.

A. Constitution

- EAC shall be constituted by the Central Government comprising a maximum of 15 members including a Chairperson and Secretary.
- The Central Government will notify committee.
- The Chairperson and the non-official member shall have a fixed term of three years, from the date of Notification by the Central Government.
- The Chairperson shall be an eminent environmental expert with understanding on environmental aspects and environmental impacts.

B. Composition

- Secretary to EAC shall invite sectoral professionals/experts with the approval of the Chairperson.
- The Secretary of each EAC shall be an officer of the level equivalent to or above the level of Director, the MoEF, GoI.
- The suggested model recommended for appraisal committees is a composition of Core expert members and joined by sectoral experts. This means, core group expert members will be common to all the developmental projects in a group, whereas the sectoral experts join the core group when specific sectoral project is being appraised.
- The desired composition of state or central appraisal committee for this sector include following:
  - Environmental management specialist/ environmental regulator
  - Air and Noise quality expert
  - Occupational health
  - Geology/geo-hydrology
  - Ecologist
  - Transportation specialist

- Safety and health specialist
- Social scientist
- Crude Extraction and processing
- Chemical Engineer
- Marine Biologist/Engineer, *etc*.

C. Decision-making

The Chairperson reads the recommendations of the Committee and finalizes the draft minutes of the meeting, which are circulated by the Secretary to all the core members and sectoral experts invited to the meeting. Based on the response from the members, the minutes are finalized and signed by the Chairperson. This process for finalization of the minutes should be so organized that the time prescribed for various stages is not exceeded.

D. Operational issues

- Secretary may deal with all correspondence, formulate agenda and prepare agenda notes. Chairperson and other members may act only for the meetings.
- Chairperson of EAC shall be one among the core group having considerable professional experience with proven credentials.
- EAC shall meet at least once every month or more frequently, if so needed, to review project proposals and to offer recommendations for the consideration of the Authority.
- EAC members may inspect the site at various stages *i.e.,* during screening, scoping and appraisal, as per the need felt and decided by the Chairperson of the Committee.
- The MoEF through the Secretary of the Committee may pay/reimburse the participation expenses, honorarium *etc*., to the Chairperson and members.

i. Tenure of EAC

The tenure of Authority/Committee(s) shall be for a fixed period of three years. At the end of the three years period, the Authority and the committees need to be re-constituted. However, staggered appointment dates may be adopted to maintain continuity of members at a given point of time.

ii. Qualifying criteria for nomination of a member to EAC

While recommending nominations and while notifying the members of the Authority and Expert Committees, it shall be ensured that all the members meet the following three criteria:

- Professional qualification
- Relevant experience/Experience interfacing with environmental management
- Absence of conflict of interest

a) Professional qualification

The person should have at least

- 5 years of formal University training in the concerned discipline leading to a MA/MSc Degree, or

- in case of Engineering/Technology/Architecture disciplines, 4 years formal training in a professional training course together with prescribed practical training in the field leading to a B.Tech/B.E./B.Arch. Degree, or
- Other professional degree (e.g. Law) involving a total of 5 years of formal University training and prescribed practical training, or
- Prescribed apprenticeship/articleship and pass examinations conducted by the concerned professional association (e.g. MBA/IAS/IFS).

In selecting the individual professionals, experience gained by them in their respective fields will be taken note of.

b) Relevant experience

- Experience shall be related to professional qualification acquired by the person and be related to one or more of the expertise mentioned for the members of the Core group or the Sectoral Experts. Such experience should be a minimum of 15 years.
- When the experience mentioned in the foregoing sub-paragraph interfaces with environmental issues, problems and their management, the requirement for the length of the experience can be reduced to a minimum of 10 years.

c) Absence of conflict of interest

For the deliberations of the EAC to be independent and unbiased, all possibilities of potential conflict of interests have to be eliminated. Therefore, serving government officers; persons engaged in industry and their associations; persons associated with the formulation of development projects requiring environmental clearance, and persons associated with environmental activism shall not be considered for membership of EAC.

iii. Age

Below 70 years for the members and below 72 years for the Chairperson of the EAC. The applicability of the age is at the time of the Notification of the EAC by the Central Government.

Summary regarding the eligibility criteria for Chairperson and Members of the EAC is given in Table 5-4.

Table 5-3: EAC: Eligibility Criteria for Chairperson/ Members / Secretary

S. No.	Attribute		Requirement		
			Core Members/Sectoral Expert members	Secretary	Chairperson
1	Professional qualification as per the Notification		Compulsory	Compulsory	Compulsory
2	Experience (Fulfilling any one of a, b, c)	a	Professional Qualification + 15 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification + 15 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification + 15 years of experience in one of the expertise area mentioned in the Appendix VI

S. No.	Attribute		Requirement		
			Core Members/Sectoral Expert members	**Secretary**	**Chairperson**
		b	Professional Qualification +PhD+10 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification +PhD+10 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification +PhD+10 years of experience in one of the expertise area mentioned in Appendix VI
		c	Professional Qualification +10 years of experience in one of the expertise area mentioned in the Appendix VI + 5 years interface with environmental issues, problems and their management	Professional Qualification +10 years of experience in one of the expertise area mentioned in the Appendix VI + 5 years interface with environmental issues, problems and their management	----------
3	Test of independence (conflict of interest) and minimum grade of the Secretary of the Committees		Shall not be a serving government officer Shall not be a person engaged in industry and their associations Shall not be a person associated with environmental activism	In case of EAC, not less than a Director from the MoEF, Government of India	Shall not be a serving government officer Shall not be a person engaged in industry and their associations Shall not be a person associated with environmental activism
4	Age		Below 67 years at the time of Notification of the Committee	As per state Government Service Rules	Below 72 Years at the time of the Notification of the Committee
5	Membership in Core committees		Only one other than this nomination is permitted	Shall not be a member in other SEIAA/EAC/SEAC	Shall not be a member in any other SEIAA/EAC/SEAC
6	Membership of Sectoral Experts		Only three other than this nomination is permitted	Shall not be a member in other SEIAA/EAC/SEAC	
7	Tenure of earlier appointment (continuous)		Only one term before this in continuity is permitted	Not applicable	Only one term before this in continuity is permitted
8	Eminent environmental expertise with understanding on environmental aspects and impacts		Desirable	Not applicable	Compulsory

Notes:

1. Core members are the members in EAC/SEAC, who are common for all the types of developmental activities, whereas, sectoral expert members will join for the specific developmental sectors. Core members may be limited to about 12.
2. Sectoral expert members: Sectoral Expert members are the members who join the EAC/SEAC, when corresponding sector is being reviewed/appraised. At a given sectoral review, a maximum of three sectoral expert members may join. Therefore the total number of expert members in EAC does not exceed 15.
3. A member after continuous membership in two terms (six years) shall not be considered for further continuation. His/her nomination may be reconsidered after a gap of one term (three years), if other criteria meet.
4. Chairperson/Member (core or sectoral expert) once notified may not be removed prior to the tenure of 3 years with out cause and proper enquiry. A member after continuous membership in two terms (6 years) shall not be considered for further continuation. The same profile may be considered for nomination after a gap three years, i.e., one term if other criteria are meeting.

Other conditions

- Sectoral experts/invitees (not being a member in a Committee) can have membership in not more than four states.
- An expert member of a Committee shall not have membership continuously in the same committee for more than two terms *i.e.,* six years. They can be nominated after a gap of three years, *i.e.,* one term.
- When a member of Committee has been associated with any development project, which comes for environmental clearance, he/she may not participate in the deliberations and the decisions in respect to that particular project.
- At least four members shall be present in each meeting to fulfill the quorum
- If a member does not consecutively attend six meetings, without prior intimation to the Committee his/her membership may be terminated by the Notifying Authority. Prior information for absence due to academic pursuits, career development and national/state-endorsed programmes may be considered as genuine grounds for retention of membership.

Annexure I
A Compilation of Legal Instruments

Sl. No.	Legal Instrument (Type, Reference, Year)	Responsible Ministries or Bodies	Chemical Use Categories/ Pollutants	Objective of Legislation	Relevant Articles/Provisions
1	Air (Prevention and Control of Pollution) Act, 1981 amended 1987	Central Pollution Control Board and State Pollution Control Boards	Air pollutants from chemical industries	The prevention, control and abatement of air pollution	Section 2: Definitions Section 21: Consent from State Boards Section 22: Not to allow emissions exceeding prescribed limits Section 24: Power of Entry and Inspection Section 25: Power to Obtain Information Section 26: Power to Take Samples Section 37-43: Penalties and Procedures
2	Air (Prevention and Control of Pollution) (Union Territories) Rules, 1983	Central Pollution Control Board and State Pollution Control Boards	Air pollutants from chemical industries	The prevention, control and abatement of air pollution	Rule 2: Definitions Rule 9: Consent Applications
3	Water (Prevention and Control of Pollution) Act, 1974 amended 1988	Central Pollution Control Board and State Pollution Control Boards	Water Pollutants from water polluting industries	The prevention and control of water pollution and also maintaining or restoring the wholesomeness of water	Section 2: Definitions Section 20: Power to Obtain Information Section 21: Power to Take Samples Section 23: Power of Entry and Inspection Section 24: Prohibition on Disposal Section 25: Restriction on New Outlet and New Discharge Section 26: Provision regarding existing discharge of sewage or trade effluent Section 27: Refusal or withdrawal of consent by state boards Section 41-49: Penalties and Procedures
4	Water (Prevention and Control of Pollution) Rules, 1975	Central Pollution Control Board and State Pollution Control Boards	Water Pollutants from water polluting industries	The prevention and control of water pollution and also maintaining or restoring the wholesomeness of water	Rule 2: Definitions Rule 30: Power to take samples Rule 32: Consent Applications

5	The Environment (Protection) Act, 1986, amended 1991	Ministry of Environment and Forests, Central Pollution Control Board and State Pollution Control Boards	All types of environmental pollutants	Protection and Improvement of the Environment	Section 2: Definitions Section 7: Not to allow emission or discharge of environmental pollutants in excess of prescribed standards Section 8: Handing of Hazardous Substances Section 10: Power of Entry and Inspection Section 11: Power to take samples Section 15-19: Penalties and Procedures
6	Environmental (Protection) Rules, 1986 (Amendments in 1999, 2001, 2002, 2002, 2002, 2003, 2004)	Ministry of Environment and Forests, Central Pollution Control Board and State Pollution Control Boards	All types of Environmental Pollutants	Protection and Improvement of the Environment	Rule 2: Definitions Rule 3: Standards for emission or discharge of environmental pollutants Rule 5: Prohibition and restriction on the location of industries and the carrying on process and operations in different areas Rule 13: Prohibition and restriction on the handling of hazardous substances in different areas Rule 14: Submission of environmental statement
7	Hazardous Waste (Management and Handling) Rules, 1989 amended 2000 and 2003	MoEF, CPCB, SPCB, DGFT, Port Authority and Customs Authority	Hazardous Wastes generated from industries using hazardous chemicals	Management & Handling of hazardous wastes in line with the Basel convention	Rule 2: Application Rule 3: Definitions Rule 4: Responsibility of the occupier and operator of a facility for handling of wastes Rule 4A: Duties of the occupier and operator of a facility Rule 4B: Duties of the authority Rule 5: Grant of authorization for handling hazardous wastes Rule 6: Power to suspend or cancel authorization Rule 7: Packaging, labeling and transport of hazardous wastes Rule 8: Disposal sites Rule 9: Record and returns Rule 10: Accident reporting and follow up Rule 11: Import and export of hazardous waste for dumping and disposal Rule 12: Import and export of hazardous waste for recycling and reuse Rule 13: Import of hazardous wastes Rule 14: Export of hazardous waste

					Rule 15: Illegal traffic Rule 16: Liability of the occupier, transporter and operator of a facility Rule 19: Procedure for registration and renewal of registration of recyclers and re-refiners Rule 20: Responsibility of waste generator
8	Manufacture Storage and Import of Hazardous Chemicals Rules, 1989 amended 2000	Ministry of Environment & Forests, Chief Controller of Imports and Exports, CPCB, SPCB, Chief Inspector of Factories, Chief Inspector of Dock Safety, Chief Inspector of Mines, AERB, Chief Controller of Explosives, District Collector or District Emergency Authority, CEES under DRDO	Hazardous Chemicals - Toxic, Explosive, Flammable, Reactive	Regulate the manufacture, storage and import of Hazardous Chemicals	Rule 2: Definitions Rule 4: responsibility of the Occupier Rule 5: Notification of Major Accidents Rule 7-8: Approval and notification of site and updating Rule 10-11: Safety Reports and Safety Audit reports and updating Rule 13: Preparation of Onsite Emergency Plan Rule 14: Preparation of Offsite Emergency Plan Rule 15: Information to persons likely to get affected Rule 16: Proprietary Information Rule 17: Material Safety Data Sheets Rule 18: Import of Hazardous Chemicals
9	Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996	CCG, SCG, DCG, LCG and MAH Units	Hazardous Chemicals - Toxic, Explosive, Flammable, Reactive	Emergency Planning Preparedness and Response to chemical accidents	Rule 2: Definitions Rule 5: Functions of CCG Rule 7: Functions of SCG Rule 9: Functions of DCG Rule 10: Functions of LCG
10	Ozone Depleting Substances (Regulation and Control) Rules, 2000	MoEF	Ozone Depleting Substances	Regulate the production, import, use, sale, purchase and phase-out of the ODS	Rule 2: Definitions Rule 3: Regulation of production and consumption of ozone depleting substances Rule 4: Prohibition on export to or import from countries not specified in Schedule VI Rule 5: Ozone depleting substances are to be exported to or imported from countries specified in Schedule VI under a license Rule 6: Regulation of the sale of ozone depleting substances Rule 7: Regulation on the purchase of ozone

					depleting substances Rule 8: Regulation on the use of ozone depleting substance Rule 9: Prohibition on new investments with ozone depleting substances Rule 10: Regulation of import, export and sale of products made with or containing ozone depleting substances Rule 11: Regulation on reclamation and destruction of ozone depleting substances Rule 12: Regulation on manufacture, import and export of compressors Rule 13: Procedure for registration, cancellation of registration and appeal against such orders Rule 14: Monitoring and reporting requirements
11	EIA Notification, 1994	MoEF, SPCB	Chemicals/pollutants expected to be generated from industrial activities	Requirement of environmental clearance before establishment of or modernization / expansion of certain type of industries/ projects.	Rule 2: Requirements and procedure for seeking environmental clearance of projects
12	Public Liability Insurance Act, 1991 amended 1992	Ministry of Environment & Forests, District Collector	Hazardous Substances	To provide immediate relief to persons affected by accident involving hazardous substances	Section 2: Definitions Section 3: Liability to give relief in certain cases on principle of no fault Section 4: Duty of owner to take out insurance policy Section 7A: Establishment of Environmental Relief Fund Section 14-18: Penalties and Offences
13	Public Liability Insurance Rules, 1991 amended 1993	Ministry of Environment & Forests, District Collector	Hazardous Substances	To provide immediate relief to persons affected by accident involving hazardous substances and also for Establishing an Environmental Relief fund	Rule 2: Definitions Rule 6: Establishment of administration of fund Rule 10: Extent of liability Rule 11: Contribution of the owner to environmental relief fund
14	Factories Act, 1948	Ministry of Labour,	Chemicals as	Control of workplace	Section 2: Interpretation

		DGFASLI and Directorate of Industrial Safety and Health/Factories Inspectorate	specified in the Table	environment, and providing for good health and safety of workers	Section 6: Approval, licensing and registration of factories Section 7A: General duties of the occupier Section 7B: General duties of manufacturers etc., as regards articles and substances for use in factories Section 12: Disposal of wastes and effluents Section 14: Dust and fume Section 36: Precautions against dangerous fumes, gases, etc. Section 37: Explosion or inflammable dust, gas, etc. Chapter IVA: Provisions relating to Hazardous processes Section 87: Dangerous operations Section 87A: Power to prohibit employment on account of serious hazard Section 88: Notice of certain accident Section 88A: Notice of certain dangerous occurrences Chapter X: Penalties and procedures
15	The Petroleum Act, 1934	Ministry of Petroleum and Natural Gas	Petroleum (Class A, B and C - as defined in the rules)	Regulate the import, transport, storage, production, refining and blending of petroleum	Section 2: Definitions Section 3: Import, transport and storage of petroleum Section 5: Production, refining and blending of petroleum Section 6: Receptacles of dangerous petroleum to show a warning Section 23-28 Penalties and Procedure
16	The Petroleum Rules, 2002	Ministry of Petroleum and Natural Gas, Ministry of Shipping (for notification of authorized ports for import), Ministry of Environment & Forests or SPCB (for clearance of establishment of loading/unloading facilities at	Petroleum (Class A, B and C - as defined in the rules)	Regulate the import, transport, storage, production, refining and blending of petroleum	Rule 2: Definition Chapter I part II: General Provision Chapter II: Importation of Petroleum Chapter III: Transport of Petroleum Chapter VII: Licenses

		ports) Chief Controller of Explosives, district authority, Commissioner of Customs, Port Conservator, State Maritime Board (Import)			
17	The Explosives Act, 1884	Ministry of Commerce and Industry (Department of Explosives)	Explosive substances as defined under the Act	To regulate the manufacture, possession, use, sale, transport, export and import of explosives with a view to prevent accidents	Section 4: Definition Section 6: Power for Central government to prohibit the manufacture, possession or importation of especially dangerous explosives Section 6B: Grant of Licenses
18	The Explosive Rules, 1983	Ministry of Commerce and Industry and Chief Controller of Explosives, port conservator, customs collector, railway administration	Explosive substances as defined under the Act	To regulate the manufacture, possession, use, sale, transport, export and import of explosives with a view to prevent accidents	Rule 2: Definition Chapter II: General Provisions Chapter III: Import and Export Chapter IV: Transport Chapter V: Manufacture of explosives Chapter VI: Possession sale and use Chapter VII: Licenses
19	The Gas Cylinder Rules, 2004	Ministry of Commerce and Industry and Chief Controller of Explosives, port conservator, customs collector, DGCA, DC, DM, Police (sub inspector to commissioner)	Gases (Toxic, non toxic and non flammable, non toxic and flammable, Dissolved Acetylene Gas, Non toxic and flammable liquefiable gas other than LPG, LPG	Regulate the import, storage, handling and transportation of gas cylinders with a view to prevent accidents	Rule 2: Definition Chapter II: General Provisions Chapter III: Importation of Cylinder Chapter IV: Transport of Cylinder Chapter VII: Filling and Possession
20	The Static and Mobile Pressure Vessels (Unfired) Rules, 1981	Ministry of Commerce and Industry and Chief Controller of Explosives, port conservator, customs collector, DGCA, DC, DM, Police (sub inspector to commissioner)	Gases (Toxic, non toxic and non flammable, non toxic and flammable, Dissolved Acetylene Gas,	Regulate the import, manufacture, design, installation, transportation, handling, use and testing of mobile and static pressure vessels (unfired) with a view to prevent accidents	Rule 2: Definition Chapter III: Storage Chapter IV: Transport Chapter V: Licenses

			Non toxic and flammable liquefiable gas other than LPG, LPG		
21	The Motor Vehicle Act, 1988	Ministry of Shipping, Road Transport and Highways	Hazardous and Dangerous Goods	To consolidate and amend the law relating to motor vehicles	Section 2: Definition Chapter II: Licensing of drivers of motor vehicle Chapter VII: Construction equipment and maintenance of motor vehicles
22	The Central Motor Vehicle Rules, 1989	Ministry of Shipping, Road Transport and Highways	Hazardous and Dangerous Goods	To consolidate and amend the law relating to motor vehicles including to regulate the transportation of dangerous goods with a view to prevent loss of life or damage to the environment	Rule 2: Definition Rule 9: Educational qualification for driver's of goods carriages carrying dangerous or hazardous goods Rule 129: Transportation of goods of dangerous or hazardous nature to human life Rule 129A: Spark arrestors Rule 130: Manner of display of class labels Rule 131: Responsibility of the consignor for safe transport of dangerous or hazardous goods Rule 132: Responsibility of the transporter or owner of goods carriage Rule 133: Responsibility of the driver Rule 134: Emergency Information Panel Rule 135: Driver to be instructed Rule 136: Driver to report to the police station about accident Rule 137: Class labels
23	The Custom Act, 1962	CBEC, Ministry of Finance	Hazardous Goods	To prevent entry of illegal hazardous goods or banned goods including hazardous or banned chemicals	Section 2: definitions Section 11: Power to Prohibit Importation or Exportation of Goods
24	The Merchant Shipping Act, 1958 amended in 2002 and 2003	Ministry of Shipping, Road Transport and Highways	All packaged cargo including Dangerous and hazardous goods as defined in the rules	For safe handling and transportation of cargo including dangerous goods to prevent accident	Section 3: Definitions Section 331: Carriage of Dangerous Goods

25	Merchant Shipping (carriage of Cargo) Rules 1995	Ministry of Shipping, Road Transport and Highways	All packaged cargo including Dangerous and hazardous goods as defined in the rules	For safe handling and transportation of cargo including dangerous goods to prevent accident	
26	The Indian Port Act, 1908	Ministry of Shipping, Road Transport and Highways	All Chemicals - handling and storage	For control of activities on ports including safety of shipping and conservation of ports	Section 2: Definitions Chapter IV: Rules for the safety of shipping and the conservation of ports Chapter VII: Provisions with respect to penalties
27	The Dock Workers, (Safety, Health and Welfare) Act, 1986	Ministry of Labour, DGFASLI and Directorate of Dock Safety	All Chemicals termed as dangerous goods	Safety of Dock workers including handling of dangerous goods	
28	The Dock Workers, (Safety, Health and Welfare) Rules, 1990	Ministry of Labour, DGFASLI and Directorate of Dock Safety	All Chemicals termed as dangerous goods	Safety of Dock workers including handling of dangerous goods	

Annexure II
Form 1 (Application Form for Obtaining EIA Clearance)

FORM 1

(I) Basic Information

Name of the Project:

Location / site alternatives under consideration:

Size of the Project: *

Expected cost of the project:

Contact Information:

Screening Category:

- *Capacity corresponding to sectoral activity (such as production capacity for manufacturing, mining lease area and production capacity for mineral production, area for mineral exploration, length for linear transport infrastructure, generation capacity for power generation etc.,)*

(II) Activity

1. **Construction, operation or decommissioning of the Project involving actions, which will cause physical changes in the locality (topography, land use, changes in water bodies, etc.)**

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities /rates, wherever possible) with source of information data
1.1	Permanent or temporary change in land use, land cover or topography including increase in intensity of land use (with respect to local land use plan)		
1.2	Clearance of existing land, vegetation and buildings?		
1.3	Creation of new land uses?		
1.4	Pre-construction investigations e.g. bore houses, soil testing?		
1.5	Construction works?		

1.6	Demolition works?		
1.7	Temporary sites used for construction works or housing of construction workers?		
1.8	Above ground buildings, structures or earthworks including linear structures, cut and fill or excavations		
1.9	Underground works including mining or tunneling?		
1.10	Reclamation works?		
1.11	Dredging?		
1.12	Offshore structures?		
1.13	Production and manufacturing processes?		
1.14	Facilities for storage of goods or materials?		
1.15	Facilities for treatment or disposal of solid waste or liquid effluents?		
1.16	Facilities for long term housing of operational workers?		
1.17	New road, rail or sea traffic during construction or operation?		
1.18	New road, rail, air waterborne or other transport infrastructure including new or altered routes and stations, ports, airports etc?		
1.19	Closure or diversion of existing transport routes or infrastructure leading to changes in traffic movements?		
1.20	New or diverted transmission lines or pipelines?		
1.21	Impoundment, damming, culverting, realignment or other changes to the hydrology of watercourses or aquifers?		
1.22	Stream crossings?		
1.23	Abstraction or transfers of water form ground or surface waters?		
1.24	Changes in water bodies or the land surface affecting drainage or run-off?		

1.25	Transport of personnel or materials for construction, operation or decommissioning?		
1.26	Long-term dismantling or decommissioning or restoration works?		
1.27	Ongoing activity during decommissioning which could have an impact on the environment?		
1.28	Influx of people to an area in either temporarily or permanently?		
1.29	Introduction of alien species?		
1.30	Loss of native species or genetic diversity?		
1.31	Any other actions?		

2. **Use of Natural resources for construction or operation of the Project (such as land, water, materials or energy, especially any resources which are non-renewable or in short supply):**

S.No.	Information/checklist confirmation	Yes/No	Details thereof (with approximate quantities /rates, wherever possible) with source of information data
2.1	Land especially undeveloped or agricultural land (ha)		
2.2	Water (expected source & competing users) unit: KLD		
2.3	Minerals (MT)		
2.4	Construction material – stone, aggregates, and / soil (expected source – MT)		
2.5	Forests and timber (source – MT)		
2.6	Energy including electricity and fuels (source, competing users) Unit: fuel (MT), energy (MW)		
2.7	Any other natural resources (use appropriate standard units)		

3. Use, storage, transport, handling or production of substances or materials, which could be harmful to human health or the environment or raise concerns about actual or perceived risks to human health.

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
3.1	Use of substances or materials, which are hazardous (as per MSIHC rules) to human health or the environment (flora, fauna, and water supplies)		
3.2	Changes in occurrence of disease or affect disease vectors (e.g. insect or water borne diseases)		
3.3	Affect the welfare of people e.g. by changing living conditions?		
3.4	Vulnerable groups of people who could be affected by the project e.g. hospital patients, children, the elderly etc.,		
3.5	Any other causes		

4. Production of solid wastes during construction or operation or decommissioning (MT/month)

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
4.1	Spoil, overburden or mine wastes		
4.2	Municipal waste (domestic and or commercial wastes)		
4.3	Hazardous wastes (as per Hazardous Waste Management Rules)		

4.4	Other industrial process wastes		
4.5	Surplus product		
4.6	Sewage sludge or other sludge from effluent treatment		
4.7	Construction or demolition wastes		
4.8	Redundant machinery or equipment		
4.9	Contaminated soils or other materials		
4.10	Agricultural wastes		
4.11	Other solid wastes		

5. Release of pollutants or any hazardous, toxic or noxious substances to air (Kg/hr)

S.No.	**Information/Checklist confirmation**	**Yes/No**	**Details thereof (with approximate quantities/rates, wherever possible) with source of information data**
5.1	Emissions from combustion of fossil fuels from stationary or mobile sources		
5.2	Emissions from production processes		
5.3	Emissions from materials handling including storage or transport		
5.4	Emissions from construction activities including plant and equipment		
5.5	Dust or odours from handling of materials including construction materials, sewage and waste		

5.6	Emissions from incineration of waste		
5.7	Emissions from burning of waste in open air (e.g. slash materials, construction debris)		
5.8	Emissions from any other sources		

6. Generation of Noise and Vibration, and Emissions of Light and Heat:

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data with source of information data
6.1	From operation of equipment e.g. engines, ventilation plant, crushers		
6.2	From industrial or similar processes		
6.3	From construction or demolition		
6.4	From blasting or piling		
6.5	From construction or operational traffic		
6.6	From lighting or cooling systems		
6.7	From any other sources		

7. Risks of contamination of land or water from releases of pollutants into the ground or into sewers, surface waters, groundwater, coastal waters or the sea:

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
7.1	From handling, storage, use or spillage of hazardous materials		
7.2	From discharge of sewage or other effluents to water or the land (expected mode and place of discharge)		
7.3	By deposition of pollutants emitted to air into the land or into water		
7.4	From any other sources		
7.5	Is there a risk of long term build up of pollutants in the environment from these sources?		

8. Risk of accidents during construction or operation of the Project, which could affect human health or the environment

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
8.1	From explosions, spillages, fires etc from storage, handling, use or production of hazardous substances		
8.2	From any other causes		
8.3	Could the project be affected by natural disasters causing environmental damage (e.g. floods, earthquakes, landslides, cloudburst etc)?		

9. Factors which should be considered (such as consequential development) which could lead to environmental effects or the potential for cumulative impacts with other existing or planned activities in the locality

S. No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
9.1	Lead to development of supporting. lities, ancillary development or development stimulated by the project which could have impact on the environment e.g.: • Supporting infrastructure (roads, power supply, waste or waste water treatment, etc.) • housing development • extractive industries • supply industries • other		
9.2	Lead to after-use of the site, which could havean impact on the environment		
9.3	Set a precedent for later developments		
9.4	Have cumulative effects due to proximity to other existing or planned projects with similar effects		

(III) Environmental Sensitivity

S.No.	Areas	Name/ Identity	Aerial distance (within 15 km.) Proposed project location boundary
1	Areas protected under international conventions, national or local legislation for their ecological, landscape, cultural or other related value		

2	Areas which are important or sensitive for ecological reasons - Wetlands, watercourses or other water bodies, coastal zone, biospheres, mountains, forests		
3	Areas used by protected, important or sensitive species of flora or fauna for breeding, nesting, foraging, resting, over wintering, migration		
4	Inland, coastal, marine or underground waters		
5	State, National boundaries		
6	Routes or facilities used by the public for access to recreation or other tourist, pilgrim areas		
7	Defence installations		
8	Densely populated or built-up area		
9	Areas occupied by sensitive man-made land uses *(hospitals, schools, places of worship, community facilities)*		
10	Areas containing important, high quality or scarce resources *(ground water resources, surface resources, forestry, agriculture, fisheries, tourism, minerals)*		
11	Areas already subjected to pollution or environmental damage. *(those where existing legal environmental standards are exceeded)*		
12	Areas susceptible to natural hazard which could cause the project to present environmental problems (*earthquakes, subsidence, landslides, erosion, flooding or extreme or adverse climatic conditions*)		

(IV). Proposed Terms of Reference for EIA studies

Annexure III
Pre-Feasibility Report

Offshore Facilities

Project Details

General

- Location Details
    - Longitude & Latitude
    - Nearest major towns and industries
    - Approach to Site
    - Road: Existing Highway/roads distance from site
    - Distance from nearest airport (existing/proposed)
    - Ecologically sensitive areas
- Secondary information on bathymetry studies
- Transportation arrangements
- New facilities needed
- Source of construction water and potable water
- Source of construction power & start up power
- Source of availability of construction material like sand, brick, stone chips, borrow earth *etc*.
- Location & vicinity plan identifying the areas proposed for plant

Techno-economic Feasibility Aspects

- Area availability & its development
- General Layout
- Access to the site for transportation of equipments, construction machinery, material *etc*.
- Water availability for consumptive use
- Fuel availability and its transportation
- Environmental aspects
- Ultimate plant capacity, which could be set up

Technical Profile of the Project

- Technical parameters of the plant & equipment.
- Meteorological data like temperature, humidity, rainfall, tides, currents, wind pressure & wind direction.
- Seismological studies of project specific design seismic parameters.
- Project implementation schedule showing various activities.

Justification of the Project

- Current Demand Scenario of the product
- Alternatives to meet the demand
- Post Project scenario on residual demand

Site Selection

- Options considered for sites
- Basis of site selection and analysis
- Support infrastructure availability at selected site
- Scope of Geo-technical / Geo-Physical studies

Future Prospects

- Ascertain the costs and benefits of the proposed project for project life
- De-rated capacities and efficiencies
- Technical and logistic constraints/ requirements of project sustainability

Project Design/Technology

- Analysis of various possible configurations for each technology or a combination of the technologies from available sources

Details of Socio-economic Consequences

- Importance of the proposed product for Quality-of-Life
- Corporate Responsibilities & Status of Compliance
- Employments and infrastructure added in the district of locations
- Status of land availability, current and post project land use variation
- R&R status compliance requirements and broad approach

The above listing is not exhaustive. Thus the proponent may provide additional necessary information, felt appropriate, to include in the pre-feasibility study report in support of selecting the site for the proposed developmental activities. The EAC during scrutiny, may specifically ask for any additional information/ data required to substantiate the requirement to prescribe the ToR for EIA studies. However, it is to make clear that all the required further information by EAC shall be mentioned in one single letter, within the prescribed time.

Onshore Facilities

Environmental Aspects

- Location Details

  - State/District/Village
  - Longitude & Latitude
  - Nearest major towns and industries
  - Approach to Site
  - Rail: Nearest Rail Head & Distance
  - Road: Existing Highway/roads distance from site
  - Distance from nearest airport (existing/proposed)
  - Distance from nearest waterways
  - Constraints if any to approach site particularly for construction materials, plants and equipments *etc*.

- Details of ecologically sensitive areas like tropical forests, biosphere reserves, national park, sanctuaries, important lakes, endangered species of flora & fauna and distance from site, *etc*.

- Places of archaeological importance, river, streams, Estuary, sea, hills/mountains, historical, cultural, religious or tourist importance, defence installation, *etc*.

- Land Availability

  - Extent of land available for plant, township
  - Land use pattern (agricultural, barren, forest *etc*.,)
  - Incase of agricultural land, whether irrigated/non irrigated, number of crops
  - Land ownership (Govt. Pvt., tribal, non-tribal *etc*.,)
  - Prevailing land cost details
  - Estimation of population affected, Homestead Oustees, Land Ownership, *etc*.

Project Details

General

- Topography of the area
- Permanent features
- In case site is in flood prone area include details of the site
- Soil conditions, soil investigations, *etc*.
- Drainage patterns
- Source of consumptive water and surplus water availability
- Location in relation to River/Canal/Dam, water availability and quality
- Approved water allocation quota (drinking, irrigation and industrial use) and surplus availability
- Inter-state issues, if any
- Feasible ways of bringing water to site indicating constraints if any.
- Transportation arrangements
- New facilities needed

- Source of availability of construction material like sand, brick, stone chips, borrow earth *etc*.
- Proximity to infrastructure facilities (such as hospitals, schools, residential accommodation) available nearby
- Location & vicinity plan identifying the areas proposed for plant, colony & disposal

Techno-economic Feasibility Aspects

- Land availability & its development
- General Layout
- Access to the site for transportation of equipments, construction machinery, material *etc*.
- Water availability for cooling & consumptive use
- Fuel availability and its transportation
- Environmental and forest aspects
- Ultimate plant capacity which could be set up

Technical Profile of the Project

- Technical parameters of the plant & equipments.
- Meteorological data like temperature, humidity, rainfall, wind pressure & wind direction.
- Seismological studies of project specific design seismic parameters.
- Project implementation schedule showing various activities.

Justification of the Project

- Current Demand Scenario of the product
- Alternatives to meet the demand
- Post Project scenario on Residual Demand

Site Selection

- Options considered for sites
- Basis of site selection and analysis
- Support infrastructure availability at selected site
- Scope of geotechnical studies

Future Prospects

- Ascertain the costs and benefits of the proposed project for project life
- De-rated capacities and efficiencies
- Technical and logistic constraints/ requirements of project sustainability

Project Design/Technology

- Analysis of various possible configurations for each technology or a combination of these technologies from available manufactures

Details of Socio-economic Consequences

- Importance of the proposed product for Quality-of-Life
- Corporate Responsibilities & Status of Compliance
- Employments and infrastructure added in the district of locations
- Status of land availability, current and post project land use variation

The above listing is not exhaustive. Thus the proponent may provide additional necessary information, felt appropriate, to include in the pre-feasibility study report in support of selecting the site for the proposed developmental activities. The EAC during scrutiny, may specifically ask for any additional information/ data required to substantiate the requirement to prescribe the ToR for EIA studies. However, it is to make clear that all the required further information by EAC shall be mentioned in one single letter, within the prescribed time.

Annexure IV
Types of Monitoring and Network Design Considerations

TYPES OF MONITORING AND NETWORK DESIGN CONSIDERATIONS

A. Types of Monitoring

Monitoring refers to the collection of data using a series of repetitive measurements of environmental parameters (or, more generally, to a process of systematic observation). The environmental quality monitoring programme design will be dependent upon the monitoring objectives specified for the selected area of interest. The main types of EIA monitoring activities are:

- Baseline monitoring is the measurement of environmental parameters during the pre-project period for the purpose of determining the range of variation of the system and establishing reference points against which changes can be measured. This leads to the assessment of the possible (additional available) assimilative capacity of the environmental components in pre-project period w.r.t. the standard or target level.
- Effects monitoring is the measurement of environmental parameters during project construction and implementation to detect changes which are attributable to the project to provide the necessary information to:
  - verify the accuracy of EIA predictions; and
  - determine the effectiveness of measures to mitigate adverse effects of projects on the environment.
  - Feedback from environmental effect monitoring programs may be used to improve the predictive capability of EIAs and also determine whether more or less stringent mitigation measures are needed
- Compliance monitoring is the periodic sampling or continuous measurement of environmental parameters to ensure that regulatory requirements and standards are being met.

Compliance and effects monitoring occurs during the project construction, operation, and abandonment stages. The resources and institutional set-up should be available for the monitoring at these stages. All large-scale construction projects will require some construction stage monitoring. To control the environmental hazards of construction as specified in the EIA, a monitoring program should be established to ensure that each mitigation measure is effectively implemented. There are numerous potential areas for monitoring during operations.

The scope of monitoring topics discussed in this chapter is limited to Baseline and Effects monitoring. In addition, this chapter will also discuss the Compliance monitoring during the construction phase. Post-project monitoring requirements are discussed in the EMP.

Before any field monitoring tasks are undertaken there are many institutional, scientific, and fiscal issues that must be addressed in the implementation of an environmental monitoring program. Careful consideration of these issues in the design and planning stages will help avoid many of the pitfalls associated with environmental monitoring programs. Although these issues are important but the discussions here are confined to the monitoring network design component.

B. Network Design

Analysis of Significant Environmental Issues

At the outset of planning for an environmental monitoring network, the EIA manager may not know exactly what should be monitored, when monitoring should begin, where it should monitor, which techniques should be employed, and who should take responsibility for its conduct. Because there are usually a number of objective decisions associated with network design to be made, it is important to start with an analysis of environmental issues. The scoping phase of an EIA is designed to identify and focus on the major issues. Scoping should provide a valuable source of information on the concerns that need to be addressed by the monitoring network design. These are project specific as well as specific to the environmental setting of the location where the project is proposed to be located

Hence, the network designs are associated with questions like:

- What are the expected outputs of the monitoring activity?
- Which problems do we need to address to? *etc*.

Defining the output will influence the design of the network and optimize the resources used for monitoring. It will also ensure that the network is specially designed to optimize the information on the problems at hand

What to Monitor?

The question of what to monitor is associated with the identification of VECs.

VECs are generally defined as environmental attributes or components of the environment that are valued by society as identified during the scoping stage of the project. They are determined on the basis of perceived public concerns. For example, changes to water quality and quantity could have implications on fish by affecting habitat, food supply, oxygen, and contaminant uptake. Similarly, employment and business, and economies are both VECs that serve as pathways.

The choice of VECs is also related to the perceived significant impact of the project implementation on important environmental components. In general, the significance or importance of environmental components is judged based on:

- legal protection provided (for example, rare and endangered species)
- political or public concerns (for example, resource use conflicts and sustainable development)
- scientific judgment (for example, ecological importance); or
- commercial or economic importance

However, in addition to their economic, social, political or ecological significance, the chosen VEC should also have unambiguous operational ease, be accessible to prediction and measurement; and be susceptible to hazard. Once the VECs are defined, the VECs may be directly measured (for example, extent of habitat for an endangered species). In cases where it is impossible or impractical to directly measure the VECs, the chosen measurement endpoints or environmental indicators must correspond to, or be predictive of assessment endpoints.

The chosen environmental indicators must be: 1) measurable; 2) appropriate to the scale of disturbance/ contamination; 3) appropriate to the impact mechanism; 4) appropriate

and proportional to temporal dynamics; 5) diagnostic; and 6) standardized; as well as have: 1) a low natural variability; 2) a broad applicability; and 3) an existing data series.

Where, How and How Many Times to Monitor?

These are the other components of Monitoring Network Design. These questions are best answered based on local field conditions, capacity and resources available, prevailing legal and regulatory priorities, *etc*. For this screening or reconnaissance Surveys of the study area also necessary. This may also include some simple inexpensive measurements and assimilative/dispersion modeling. The data will give some information on the prevailing special and temporal variations, and the general background air pollution in the area. The number of monitoring stations and the indicators to be measured at each station in the final permanent network may then be decided upon based on the results of the screening study as well as on the knowledge of the sources of the proposed development and prevailing local environmental/meteorological conditions. The best possible definition of the air pollution problem, together with the analysis of the resources: personnel, budget and equipment available, represent the basis for the decision on the following questions:

- What spatial density (number) of sampling stations is required? How many samples are needed and during what period (sampling (averaging) time and frequency)?
- Where should the stations be located?
- What kind of equipment should be used?
- What additional background information is needed?
  - meteorology
  - topography
  - population density
  - emission sources and emission rates
  - effects and impacts
- How will the data be made available/communicated?

C. Site Selection

This normally means that for designing a monitoring programme in an (study) area which might have an impact, several monitoring stations are needed for characterizing the baseline conditions of the impacted area. When considering the location of individual samplers, it is essential that the data collected are representative for the location and type of area without the undue influence from the immediate surroundings. In any measurement point in the study area the total ambient concentration is the representative of:

- natural background concentration
- regional background
- impact of existing large regional sources such as Industrial emissions

To obtain the information about the importance of these different contributions it is therefore necessary to locate monitoring stations so that they are representative for different impacts. In addition to the ambient pollution data, one would often need other data governing the variations such as meteorological data for air pollution, to identify and quantify the sources contributing to the measurements. When considering the location of individual samplers, it is essential that the data collected are representative for the location and type of area without undue influence from the immediate surroundings.

Annexure V
Guidance for Assessment of Baseline Components and Attributes

GUIDANCE FOR ASSESSMENT OF BASELINE COMPONENTS AND ATTRIBUTES*

Attributes	Sampling		Measurement Method	Remarks
	Network	Frequency		
A. Air (Onshore and Offshore)				
▪ Meteorological ▪ Wind speed ▪ Wind direction ▪ Dry bulb temperature ▪ Wet bulb temperature ▪ Relative humidity ▪ Rainfall ▪ Solar radiation ▪ Cloud cover	Minimum 1 site in the project impact area requirements Other additional site(s) are require depending upon the model applied or site sensitivities	Min: 1 hrly observations from continuous records	Mechanical / automatic weather station Rain gauge As per IMD As per IMD	IS 5182 Part 1-20 Sit-specific primary data is essential Secondary data from IMD, New Delhi for the nearest IMD station
Pollutants ▪ SPM ▪ RSPM ▪ SO_2 ▪ NO_2 ▪ Asbestos (parameters are given in ToR for EIA based on nature of project, raw material & process technology, location-nature/activities within of air	10 to 15 locations in the project impact area	24 hrly twice a week 8 hrly twice a week 24 hrly twice a week	▪ Gravimetric (High – Volume) ▪ Gravimetric (High – Volume with Cyclone) ▪ EPA Modified West & Gaeke method ▪ Arsenite Modified Jacob & Hochheiser ▪ NDIR technique ▪ Methylene-blue ▪ Nessler's Method ▪ Infra Red analyzer ▪ Specific Ion meter	**Monitoring Network** Minimum 2 locations in upwind side, more sites in downwind side / impact zone All the sensitive receptors need to be covered **Measurement Methods** As per CPCB standards for NAQM, 1994

Attributes	Sampling		Measurement Method	Remarks
	Network	Frequency		
B. Noise (Onshore and Offshore)				
Hourly equivalent noise levels	Same as for Air Pollution along with others Identified in study area	At lest one day continuous in each season on a working and non-working day	Instrument : Sensitive Noise level meter (preferably recording type)	Min: IS: 4954- 1968 as adopted by CPCB
Hourly equivalent noise levels	Inplant (1.5 m from machinery or high emission processes)	Same as above for day and night	Instrument : Noise level meter	CPCB / OSHA
Hourly equivalent noise levels	Highways (within 500 metres from the road edge)	Same as above for day and night	Instrument : Noise level meter	CPCB / IS : 4954-1968
Peak particle velocity	150- 200m from blast site	Based on hourly observations	PPV meter	
C. Land Environment (Onshore)				
▪ Soil ▪ Particle size distribution ▪ Texture ▪ pH ▪ Electrical conductivity ▪ Caution exchange capacity ▪ Alkali metals ▪ Sodium Absorption Ratio (SAR) ▪ Permeability ▪ Porosity	One surface sample from each landfill and/or hazardous waste site (if applicable) and prime villages, (soil samples be collected as per BIS specifications) in the study area	Season-wise	Collected and analyzed as per soil analysis reference book, M.I.Jackson and soil analysis reference book by C.A. Black	The purpose of impact assessment on soil (land environment) is to assess the significant impacts due to leaching of wastes or accidental releases and contaminating

Attributes	Sampling		Measurement Method	Remarks
	Network	Frequency		
Land Use/Landscape				
▪ Location code ▪ Total project area ▪ Topography ▪ Drainage (natural) ▪ Cultivated, forest plantations, water bodies, roads and settlements	At least 20 points along with plant boundary and general major land use categories in the study area. `	Drainage once in the study period and land use categories from secondary data (local maps) and satellite imageries	Global positioning system Topo-sheets Satellite Imageries (1:25,000) Satellite Imageries (1:25,000)	Drainage within the plant area and surrounding is very important for storm water impacts. From land use maps sensitive receptors (forests, parks, mangroves *etc*.) can be identified
D. Solid Waste (Onshore and Offshore)				
Quantity				
▪ Based on waste generated from per unit production ▪ Per capita contribution ▪ Collection, transport and disposal system ▪ Process Waste ▪ Quality (oily, chemical, biological)	For green field unites it is based on secondary data base of earlier plants.	Process wise or activity wise for respective raw material used. Domestic waste depends upon the season also	Guidelines IS 9569 : 1980 IS 10447 : 1983 IS 12625 : 1989 IS 12647 : 1989 IS 12662 (PTI) 1989	
▪ General segregation into biological/organic/inert/hazardous ▪ Loss on heating ▪ pH ▪ EC ▪ Calorific value, metals etc.	Grab and Composite samples	Process wise or activity wise for respective raw material used. Domestic waste depends upon the season also	Analysis IS 9334 : 1979 IS 9235 : 1979 IS 10158 : 1982	

Attributes	Sampling		Measurement Method	Remarks
	Network	Frequency		
Quality				
▪ Permeability And porosity ▪ Moisture pH ▪ Electrical conductivity ▪ Loss on ignition ▪ Total nitrogen ▪ Caution exchange capacity ▪ Particle size distribution ▪ Heavy metal ▪ Ansonia	Grab and Composite samples. Recyclable components have to analyzed for the recycling requirements	Process wise or activity wise for respective raw material used.	Analysis IS 9334 : 1979 IS 9235 : 1979 IS 10158 : 1982	Impacts of hazardous waste should be performed critically depending on the waste characteristics and place of discharge. For land disposal the guidelines should be followed and impacts of accidental releases should be assessed
E. Biological Environment (Onshore and Offshore)				
Aquatic ▪ Primary productivity ▪ Aquatic weeds ▪ Enumeration of ▪ phytoplankton, zooplankton and benthos ▪ Fisheries ▪ Diversity indices ▪ Trophic levels ▪ Rare and endangered species ▪ Sanctuaries / closed areas / Coastal regulation zone (CRZ) ▪ Terrestrial	Considering probable impact, sampling points and number of samples to be decided on established guidelines on ecological studies based on site eco-environment setting within 10/25 km radius from the proposed site Samples to collect from upstream and downstream of	Season changes are very important	Standards techniques (APHA et. Al. 1995, Rau and Wooten 1980) to be followed for sampling and measurement	Seasonal sampling for aquatic biota One season for terrestrial biota, in addition to vegetation studies during monsoon season Preliminary assessment Microscopic analysis of plankton and meiobenthos, studies of macrofauna, aquatic vegetation and application of indices,

Attributes	Sampling		Measurement Method	Remarks
	Network	Frequency		
▪ Vegetation – species, list, economic importance, forest produce, medicinal value ▪ Importance value index (IVI) of trees ▪ Wild animals	discharge point, nearby tributaries at down stream, and also from dug wells close to activity site			viz. Shannon, similarity, dominance IVI, *etc* Point quarter plot-less method (random sampling) for terrestrial vegetation survey.
Avifauna ▪ Rare and endangered species ▪ Sanctuaries / National park / Biosphere reserve	For forest studies, chronic as well as short-term impacts should be analyzed warranting data on micro climate conditions			Secondary data to collect from Government offices, NGOs, published literature Plankton net Sediment dredge Depth sampler Microscope Field binocular
F. Socio-economic (Onshore and Offshore)				
▪ Demographic structure ▪ Infrastructure resource base ▪ Economic resource base ▪ Health status: Morbidity pattern ▪ Cultural and aesthetic attributes	Socio-economic survey is based on proportionate, stratified and random sampling method	Different impacts occurs during construction and operational phases of the project	Primary data collection through R&R surveys (if require) or community survey are based on personal interviews and questionnaire	Secondary data from census records, statistical hard books, toposheets, health records and relevant official records available with Govt. agencies

* Project Specific

Annexure VI
Sources of Secondary Data Collection

Annexure VIA: Potential Sources of Data For EIA

	Information	Source
	Air Environment	
1.	Meteorology- Temperature, Rainfall, Humidity, Inversion, Seasonal Wind rose pattern (16 point compass scale), cloud cover, wind speed, wind direction, stability, mixing depth	⑨ Indian Meteorology Department, Pune
2.	Ambient Air Quality- 24 hourly concentration of SPM, RPM, SO_2, NO_x, CO	⑨ Central Pollution Control Board (CPCB), ⑨ State Pollution Control Board (SPCB), ⑨ Municipal Corporations ⑨ Ministry of Environment and Forests (MoEF) ⑨ State Department of Environment (DoEN)
	Water Environment	
3.	Surface water- water sources, water flow (lean season), water quality, water usage, Downstream water users Command area development plan Catchment treatment plan	⑨ Central Water Commission (CWC), ⑨ Central Pollution Control Board (CPCB), ⑨ State Pollution Control Board (SPCB), Central Water and Power Research Institute (CWPRS), Pune ⑨ State Irrigation Department ⑨ Hydel Power generation organizations such as NHPC, State SEBs
4.	Ground Water- groundwater recharge rate/withdrawal rate, ground water potential groundwater levels (pre monsoon, post monsoon), ground water quality, changes observed in quality and quantity of ground water in last 15 years	⑨ Central Ground Water Board (CGWB) ⑨ Central Ground Water Authority (CGWA) ⑨ State Ground Water Board (SGWB) ⑨ National Water Development Authority (NWDA)
5.	Coastal waters- water quality, tide and current data, bathymetry	⑨ Department of Ocean Development, New Delhi ⑨ State Maritime Boards ⑨ Naval Hydrographer's Office, Dehradun ⑨ Port Authorities ⑨ National Institute of Oceanography (NIO), Goa
	Biological Environment	
6.	Description of Biological Environment- inventory of flora and fauna in 7 km radius, endemic species, endangered species, Aquatic Fauna, Forest land, forest type and density of vegetation, biosphere, national parks, wild life sanctuaries, tiger reserve, elephant reserve, turtle nesting ground, core zone of biosphere reserve, habitat of migratory birds, routes of migratory birds	⑨ District Gazetteers ⑨ National Remote Sensing Agency (NRSA), Hyderabad ⑨ Forest Survey of India, Dehradun ⑨ Wildlife Institute of India ⑨ World Wildlife Fund ⑨ Zoological Survey of India ⑨ Botanical Survey of India ⑨ Bombay Natural History Society, (BNHS), Mumbai ⑨ State Forest Departments ⑨ State Fisheries Department ⑨ Ministry of Environment and Forests ⑨ State Agriculture Departments ⑨ State Agriculture Universities
	Land Environment	
7.	Geographical Information-Latitude, Longitude, Elevation (above MSL)	⑨ Toposheets of Survey of India, Pune ⑨ National Remote Sensing Agency (NRSA), Hyderabad ⑨ Space Application Centre (SAC), Ahmedabad

	Information	Source
8.	Nature of Terrain, topography map indicating contours (1:2500 scale)	⑨ Survey of India Toposheets ⑨ National Remote Sensing Agency (NRSA), Hyderabad ⑨ State Remote Sensing Centre, ⑨ Space Application Centre (SAC), Ahmedabad
9.	Hydrogeology- Hydrogeological report (in case of ground water is used/area is drought prone/wastewater is likely to discharged on land) Geomorphological analysis (topography and drainage pattern) Geological analysis (Geological Formations/Disturbances- geological and structural maps, geomorphological contour maps, structural features, including lineaments, fractures, faults and joints) Hydrogeological analysis (disposition of permeable formations, surface-ground water links, hydraulic parameter determination etc) Analysis of the natural soil and water to assess pollutant absorption capacity	⑨ NRSA, Hyderbad ⑨ Survey of India Toposheets ⑨ Geological Survey of India ⑨ State Geology Departments ⑨ State Irrigation Department ⑨ Department of Wasteland Development, Ministry of Rural Areas ⑨ National Water Development Authority (NWDA)
10.	Nature of Soil, permeability, erodibility classification of the land	⑨ Agriculture Universities ⑨ State Agriculture Department ⑨ Indian Council for Agriculture Research ⑨ State Soil Conservation Departments ⑨ National Bureau of Soil Survey and Landuse Planning ⑨ Central Arid Zone Research Institute (CAZRI), Jodhpur
11.	Landuse in the project area and 10 km radius of the periphery of the project	⑨ Survey of India- Toposheets ⑨ All India Soil and Landuse Survey; Delhi ⑨ National Remote Sensing Agency (NRSA), Hyderabad ⑨ Town and County Planning Organisation ⑨ State Urban Planning Department ⑨ Regional Planning Authorities (existing and proposed plans) ⑨ Village Revenue Map- District Collectorate ⑨ Directorate of Economics and Statistics-State Government ⑨ Space Application Centre, Ahmedabad
12.	Coastal Regulation Zones- CRZMP, CRZ classification, Demarcation of HTL and LTL*	⑨ Urban Development Department ⑨ State Department of Environment ⑨ State Pollution Control Board ⑨ Space Application Centre* ⑨ Centre for Earth Sciences Studies, Thiruvanthapuram* ⑨ Institute of Remote Sensing, Anna University Chennai* ⑨ Naval Hydrographer's Office, Dehradun* ⑨ National Institute of Oceanography, Goa* ⑨ National Institute of Ocean Technology, Chennai ⑨ Centre for Earth Science Studies

* *Agencies authorized for approval of demarcation of HTL and LTL*

	Information	Source
	Social	
13.	Socioeconomic - population, number of houses and present occupation pattern within 7 km from the periphery of the project	⑨ Census Department ⑨ District Gazetteers- State Government ⑨ District Statistics- District Collectorate ⑨ International Institute of Population Sciences, Mumbai (limited data) ⑨ Central Statistical Organisation
14.	Monuments and heritage sites	District Gazetteer Archeological Survey of India, INTACH District Collectorate Central and State Tourism Department State Tribal and Social Welfare Department
	Natural Disasters	
15.	Seismic data (Mining Projects)- zone no, no of earthquakes and scale, impacts on life, property existing mines	⑨ Indian Meteorology Department, Pune ⑨ Geological Survey of India
16.	Landslide prone zone, geomorphological conditions, degree of susceptibility to mass movement, major landslide history (frequency of occurrence/decade), area affected, population affected	⑨ Space Application Centre
17.	Flood/cyclone/droughts- frequency of occurrence per decade, area affected, population affected	⑨ Natural Disaster Management Division in Department of Agriculture and Cooperation ⑨ Indian Meteorological Department
	Industrial	
18.	Industrial Estates/Clusters, Growth Centres	⑨ State Industrial Corporation ⑨ Industrial Associations ⑨ State Pollution Control Boards ⑨ Confederation Indian Industries (CII) ⑨ FICCI
19.	Physical and Chemical properties of raw material and chemicals (Industrial projects); fuel quality	⑨ Material and Safety Data Sheets ⑨ ENVIS database of Industrial Toxicological Research Centre, Lucknow ⑨ Indian Institute Petroleum
20.	Occupational Health and Industrial Hygiene- major occupational health and safety hazards, health and safety requirements, accident histories	⑨ Central Labour Institute, Mumbai ⑨ Directorate of Industrial Safety ⑨ ENVIS Database of Industrial Toxicological Research Centre, Lucknow ⑨ National Institute of Occupational Health, Ahmedabad
21.	Pollutant release inventories (Existing pollution sources in area within 10 km radius)	⑨ Project proponents which have received EC and have commenced operations
22.	Water requirement (process, cooling water, DM water, Dust suppression, drinking, green belt, fire service)	⑨ EIA Reports ⑨ National and International Benchmarks

Annexure VIB: Summary of Available Data with Potential Data Sources for EIA

	Agency	Information Available
1.	Archaeological Survey of India Department of Culture Government of India Janpath, New Delhi - 110011 Asi@del3.vsnl.net.in	⑨ Inventory of monuments and sites of national importance- Listing and documentation of monuments according to world heritage, pre historic, proto historic and secular, religious places and forts
2.	Botanical Survey Of India P-8, Brabourne Road Calcutta 700001 Tel#033 2424922 Fax#033 2429330 Email: envis@cal2.vsnl.net.in. . RO - Coimbatore, Pune, Jodhpur, Dehradun, Allahabad, Gantok, Itanagar, Port Blair	⑨ Photodiversity documentation of flora at National, State and District level and flora of protected areas, hotspots, fragile ecosystems, sacred groves etc ⑨ Identification of threatened species including endemics, their mapping, population studies ⑨ Database related to medicinal plants, rare and threatened plant species ⑨ Red data book of Indian plants (Vol 1,2, and 3) ⑨ Manual for roadside and avenue plantation in India
3.	Bureau of Indian Standards Manak Bhawan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002 Tel#3230131, 3233375, 3239402 (10 lines) Fax : 91 11 3234062, 3239399, 3239382 Email- bis@vsnal.com	⑨ Bureau of Indian Standards Committees on Earthquake Engineering and Wind Engineering have a Seismic Zoning Map and the Wind Velocity Map including cyclonic winds for the country
4.	Central Water Commission (CWC) Sewa Bhawan, R.K.Puram New Delhi - 110066 cmanoff@niccwc.delhi.nic.in RO- Bangalore, Bhopal, Bhubaneshwar, Chandigarh, Coimbatore/Chennai, Delhi, Hyderabad, Lucknow, Nagpur, Patna, Shillong, Siliguri and Vadodara	⑨ Central Data Bank -Collection, collation and Publishing of Hydrological, Hydrometeorological, Sediment and Water Quality data-. ⑨ Basin wise Master Plans ⑨ Flood atlas for India ⑨ Flood Management and Development and Operation of Flood Forecasting System- CWC operate a network of forecasting stations Over 6000 forecasts are issued every year with about 95% of the forecasts within the permissible limit. ⑨ Water Year Books, Sediment Year Books and Water Quality Year Books. ⑨ Also actively involved in monitoring of 84 identified projects through National, State and Project level Environmental Committees for ensuring implementation of environmental safeguards
5.	Central Ground Water Board (HO) N.H.IV, New CGO Complex, Faridabad - 121001 RO - Guwahati, Chandigarh, Ahemadabad, Trivandrum, Calcutta, Bhopal, Lucknow, Banglore, Nagpur, Jammu, Bhubneshwar, Raipur, Jaipur, Chennai, Hyderabad, Patna	⑨ surveys, exploration, monitoring of ground water development

[16] *Based on web search and literature review*

6.	Central Pollution Control Board Parivesh Bhawan, CBD-cum-Office Complex East Arjun Nagar, DELHI - 110 032 INDIA E-mail : cpcb@alpha.nic.in	⑨ National Air Quality Monitoring Programme ⑨ National River Water Quality Monitoring Programme- Global Environment Monitoring , MINARS ⑨ Zoning Atlas Programme ⑨ Information on 17 polluting category industries (inventory, category wise distribution, compliance, implementation of pollution control programmes
7.	Central Arid Zone Research Institute, Jodhpur Email : cazri@x400.nicgw.nic.in Regional Centre at Bhuj in Gujarat	⑨ AGRIS database on all aspects of agriculture from 1975 to date ⑨ Also have cell on Agriculture Research Information System; ⑨ Working on ENVIS project on desertification ⑨ Repository of information on the state of natural resources and desertification processes and their control ⑨ The spectrum of activities involves researches on basic resource inventories; monitoring of desertification, rehabilitation and management of degraded lands and other areas
8.	Central Inland Capture Fisheries Research Institute, Barrackpore-743101, Tel#033-5600177 Fax#033-5600388 Email : cicfri@x400.nicgw.nic.in	⑨ Data Base on Ecology and fisheries of major river systems of India. Biological features of commercially important riverine and estuarine fish species. Production functions and their interactions in floodplain wetlands. ⑨ Activities - Environmental Impact Assessment for Resource Management ; Fisheries Resource surveys
9.	Central Institute of Brackish Water Aquaculture 141, Marshalls Road, Egmore , Chennai - 600 008, Tel# 044-8554866, 8554891, Director (Per) 8554851 Fax#8554851,	⑨ Repository of information on brackish water fishery resources with systematic database of coastal fishery resources for ARIS ⑨ Agricultural Research Information System (ARIS) database covers State wise data on soil and water quality parameters, land use pattern, production and productivity trends, ⑨ Social, economic and environmental impacts of aquaculture farming, ⑨ Guidelines and effluent standards for aquaculture farming
10.	Central Marine Fisheries Research Institute (CMFRI), Cochin	⑨ Assessing and monitoring of exploited and un-exploited fish stocks in Indian EEZ ⑨ Monitoring the health of the coastal ecosystems, particularly the endangered ecosystems in relation to artisanal fishing, mechanised fishing and marine pollution ⑨ The institute has been collecting data on the catch and effort and biological characteristics for nearly half a century based on scientifically developed sampling scheme, covering all the maritime States of the country ⑨ The voluminous data available with the institute is managed by the National Marine Living Resources Data Centre (NMLRDC)
11.	Central Water and Power Research Station, Pune Tel#020-4391801-14; 4392511; 4392825 Fax #020-4392004,4390189	⑨ Numerical and Physical models for hydro-dynamic simulations
12.	Central Institute of Road Transport, Bhosari, Pune 411 026, India. Tel : +91 (20) 7125177, 7125292, 7125493, 7125494	⑨ Repository of data on all aspects of performance of STUs and a host of other related road transport parameters

13.	Department of Ocean Development	⑨ Assessment of environment parameters and marine living resources (primary and secondary) in Indian EEZ (Nodal Agency NIO Kochi) ⑨ Stock assessment, biology and resource mapping of deep sea shrimps, lobsters and fishes in Indian EEZ (Nodal agency-Fisheries Survey of India) ⑨ Investigations of toxical algal blooms and benthic productivity in Indian EEZ (Nodal agency- Cochin University of Science and technology) ⑨ Coastal Ocean Monitoring and Prediction System (COMAP) - monitoring and modelling of marine pollution along entire Indian coast and islands. Parameters monitored are temp, salinity, DO, pH, SS, BOD, inorganic phosphate, nitrate, nitrite, ammonia, total phosphorus, total nitrite, total organic carbon, petroleum hydrocarbons, pathogenic vibros, pathogenic E.coli, shigella, salmonella, heavy metals (Cd, Hg, Pb) and pesticide residues (DDT, BHC, Endosulfan). Monitoring is carried out along the ecologically sensitive zones and urban areas (NIO Mumbai- Apex coordinating agency). ⑨ Sea Level Measurement Programe (SELMAM)- sea level measurement at selected stations (Porbandar, Bombay, Goa, Cochin, Tuticorin, Madras, Machilipatnam, Visakhapatnam, Paradeep, Calcutta and Kavaratti (Lakshadweep Island)) along Indian coast and islands using modern tide gauges ⑨ Detailed coastal maps through Survey of India showing contour at 1/2 a metre interval in the scale of 1:25000. (Nellore- Machhalipatnam work already over) ⑨ Marine Data Centre (MDC) IMD for Ocean surface meteorology, GSI for marine geology, SOI for tide levels, Naval Hydrographic Office for bathymetry, NIO Goa for physical chemical and biological oceanography, NIO Mumbai for marine pollution, CMFRI for coastal fisheries, Institute of Ocean Management Madras for coastal geomorphology ⑨ DOD has setup Indian National Centre for Ocean Information Services (INCOIS) at Hyderabad for generation and dissemination of ocean data products (near real time data products such as sea surface temperature, potential fishing zones, upwelling zones, maps, eddies, chlorophyll, suspended sediment load etc). MDC will be integrated with INCOIS ⑨ Integrated Coastal and Marine Area Management (ICMAM) programme - GIS based information system for management of 11 critical habitats namely Pichavaram, Karwar, Gulf of Mannar, Gulf of Khambat, Gulf of Kutch, Malvan, Cochin, Coringa mangroves, Gahirmata, Sunderbans and Kadamat (Lakshadeep) ⑨ Wetland maps for Tamil Nadu and Kerala showing the locations of lagoons, backwaters, estuaries, mudflats etc (1:50000 scale) ⑨ Coral Reef Maps for Gulf of Kachch, Gulf of Mannar, Andaman and Nicobar and Lakshadeep Islands (1:50,000 scale) indicating the condition of corals, density etc
14.	Environment Protection Training and Research Institute Gachibowli, Hyderabad - 500 019, India Phone: +91-40-3001241, 3001242, 3000489 Fax: +91-40- 3000361 E-mail: info@eptri.com	⑨ Environment Information Centre- has appointed EPTRI as the Distributed Information Centre for the Eastern Ghats region of India. EIC Collaborates with the Stockholm Environment Institute Sweden Database on Economics of Industrial Pollution Prevention in India Database of Large and Medium Scale Industries of Andhra Pradesh Environmental Status of the Hyderabad Urban Agglomeration Study on 'water pollution-health linkages' for a few Districts of A.P

		⑨ Environment Quality Mapping Macro level studies for six districts in the State of Andhra Pradesh Micro level studies for two study zones presenting the permissible pollutant load and scoping for new industrial categories Zonation of the IDA, Parwada which helped APIIC to promote the land for industrial development Disaster management plan for Visakhapatnam Industrial Bowl Area
15.	Forest Survey of India (FSI) Kaulagarh Road, P.O., IPE Dehradun - 248 195 Tel# 0135-756139, 755037, 754507 Fax # 91-135-759104 E-Mail : fsidir@nde.vsnl.net.in fsihq@nde.vsnl.net.in RO- Banglore, Calcutta, Nagpur and Shimla	⑨ State of Forest Report (Biannual) ⑨ National Forest Vegetation Map (Biannual exercise) (on 1: 1 million scale) ⑨ Thematic mapping on 1:50,000 scale depicting the forest type, species composition, crown density of forest cover and other landuse National ⑨ Basic Forest Inventory System ⑨ Inventory survey of non forest area ⑨ Forest inventory report providing details of area estimates, topographic description, health of forest, ownership pattern, estimation of volume and other growth parameters such as height and diameter in different types of forest, estimation of growth, regeneration and mortality of important species, volume equation and wood consumption of the area studied
16.	Geological Survey of India 27 Jawaharlal Nehru Road, Calcutta 700 016, India Telephone +91-33-2496941 FAX 91-33-2496956 gsi_chq@vsnl.com	⑨ Environmental hazards zonation mapping in mineral sector ⑨ Codification of base line information of geo-environmental appreciation of any terrain and related EIA and EMP studies ⑨ Lineament and geomorphological map of India on 1:20,000 scale. ⑨ Photo-interpreted geological and structural maps of terrains with limited field checks.
17.	Indian Council of Agriculture Research, Krishi Bhawan, New Delhi, Tel#011-338206 – ICAR complex, Goa- Agro metrology – Central Arid Zone Research Institute- Agro forestry – Central Soil salinity Research Institute, – Indian Institute of Soil Science – Central Soil and Water Conservation Research and Training Institute – National Bureau of Soil Survey and Landuse Planning	⑨ A total of 80,000 profiles at 10 kms grid across the country were analyzed to characterize the soils of India. ⑨ Detailed soil maps of the Country (1:7 million), State (1:250,000) and districts map (1:50,000) depicting extent of degradation (1:4.4 millions) have been prepared. ⑨ Thematic maps depicting soil depth, texture drainage, calcareousness, salinity, pH, slope and erosion have been published ⑨ Agro-climate characterization of the country based on moisture, thermal and sunshine regimes ⑨ Agro-ecological zones (20) and sub-zones (60) for the country were delineated based on physiography, soils, climate, Length of Growing Period and Available Water Content, and mapped on 1:4.4 million scale. ⑨ Digitization of physiography and soil resource base on 1:50,000 scale for 14 States have been completed. ⑨ .Soil fertility maps of N,P,K,S and Zn have also been developed ⑨ Water quality guidelines for irrigation and naturally occurring saline/sodic water ⑨ Calibration and verification of ground water models for predicting water logging and salinity hazards in irrigation commands
18.	Indian Bureau of Mines Indira Bhawan, Civil Lines Nagpur Ph no - 0712-533 631, Fax- 0712-533 041	⑨ National mineral inventory for 61 minerals and mineral maps ⑨ Studies on environmental protection and pollution control in regard to the mining and mineral beneficiation operations ⑨ Collection, processing and storage of data on mines, minerals and mineral-based industries, collection and maintenance of world mineral intelligence, foreign mineral legislation and other related matters

19.	Indian Meteorology Department Shivaji nagar, Pune 41100 RO- Mumbai, Chennai, Calcutta, New Delhi, Nagpur, Guwahati	⑨ Meteorological data ⑨ Background air quality monitoring network under Global Atmospheric Watch Programme (operates 10 stations) ⑨ Seismicity map, seismic zoning map; seismic occurrences and cyclone hazard monitoring; list of major earthquakes ⑨ Climatological Atlas of India , Rainfall Atlas of India and Agroclimatic Atlas of India ⑨ Monthly bulletin of Climate Diagnostic Bulletin of India ⑨ Environmental Meteorological Unit of IMD at Delhi to provide specific services to MoEF
20.	INTACH Natural Heritage, 71 Lodi Estate, New Delhi-110 003 Tel. 91-11-4645482, 4632267/9, 4631818, 4692774, 4641304 Fax : 91-11-4611290 E-mail : nh@intach.net	⑨ Listing and documentation of heritage sites identified by municipalities and local bodies (Listing excludes sites and buildings under the purview of the Archaeological Survey of India and the State Departments of Archaeology)
21.	Industrial Toxicology Research Centre Post Box No. 80, Mahatma Gandhi Marg, Lucknow-226001, Phone: +91-522-221856,213618,228227; Fax : +91-522 228227 Email: itrc@itrcindia.org	⑨ Activities include health survey on occupational diseases in industrial workers, air and water quality monitoring studies, ecotoxicological impact assessment, toxicity of chemicals, human health risk assessment ⑨ Five databases on CD-ROM in the area of environmental toxicology viz: TOXLINE, CHEMBANK, POISINDEX, POLTOX and PESTBANK. The Toxicology Information Centre provides information on toxic chemicals including household chemicals ⑨ ENVIS centre and created a full-fledged computerized database (DABTOC) on toxicity profiles of about 450 chemicals
22.	Indian Institute of Forest Management Post Box No. 357, Nehru Nagar Bhopal - 462 003 Phone # 0755-575716, 573799, 765125, 767851 Fax # 0755-572878	⑨ Consultancy and research on joint forest management (Ford Foundation, SIDA, GTZ, FAO etc)
23.	Indian Institute of Petroleum Mohkampur , Dehradun, India, 248005 0135- 660113 to 116 0135- 671986	⑨ Fuel quality characterisation ⑨ Emission factors
24.	Ministry of Environment and Forest	⑨ Survey of natural resources ⑨ National river conservation directorate ⑨ Environmental research programme for eastern and western ghats ⑨ National natural resource management system ⑨ Wetlands conservation programme- survey, demarcation, mapping landscape planning, hydrology for 20 identified wetlands National ⑨ wasteland identification programme
25.	Mumbai Metropolitan Regional Development Authority	⑨ Mumbai Urban Transport Project ⑨ Mumbai Urban Development Project ⑨ Mumbai Urban Rehabilitation Project ⑨ Information on MMR; statistics on councils and corporations Regional ⑨ Information Centre- Basic data on population, employment, industries and other sectors are regularly collected and processed

26.	Municipal Corporation of Greater Mumbai	⑨ Air Quality Data for Mumbai Municipal Area ⑨ Water quality of lakes used for water supply to Mumbai
27.	Ministry of Urban Development Disaster Mitigation and Vulnerability Atlas of India Building Materials & Technology Promotion Council G-Wing,Nirman Bhavan, New Delhi-110011 Tel: 91-11-3019367 Fax: 91-11-3010145 E-Mail: bmtpc@del2.vsnl.net.in	⑨ Identification of hazard prone area ⑨ Vulnerability Atlas showing areas vulnerable to natural disasters ⑨ Land-use zoning and design guidelines for improving hazard resistant construction of buildings and housing ⑨ State wise hazard maps (on cyclone, floods and earthquakes)
28.	Natural Disaster Management Division in Department of Agriculture and Cooperation	⑨ Weekly situation reports on recent disasters, reports on droughts, floods, cyclones and earthquakes
29.	National Bureau Of Soil Survey & Land Use Planning P.O. Box No. 426, Shankar Nagar P.O., Nagpur-440010 Tel#91-712-534664,532438,534545 Fax#:91-712-522534 RO- Nagpur, New Delhi, Banglore, Calcutta, Jorhat, Udaipur	⑨ NBSS&LUP Library has been identified as sub centre of ARIC (ICAR) for input to AGRIS covering soil science literature generated in India ⑨ Research in weathering and soil formation, soil morphology, soil mineralogy, physicochemical characterisation, pedogenesis, and landscape-climate-soil relationship. ⑨ Soil Series of India- The soils are classified as per Soil Taxonomy. The described soil series now belong to 17 States of the country. ⑨ Landuse planning- watershed management, land evaluation criteria, crop efficiency zoning ⑨ Soil Information system is developed state-wise at 1:250,000 scale. Presently the soil maps of all the States are digitized, processed and designed for final output both digital and hardcopy. The thematic layers and interpreted layers of land evaluation (land capability, land irrigability and crop suitability), Agro-Ecological Zones and soil degradation themes are prepared. ⑨ Districts level information system is developed for about 15 districts at 1: 50, 000 scale. The soil information will be at soil series level in this system. Soil resource inventory of States, districts water-sheds (1:250,000; 1:50,000; 1:10,000/8000)
30.	National Institute of Ocean Technology, Velacherry-Tambaram main road Narayanapuram Chennai, Tamil Nadu Tel#91-44-2460063 / 2460064/ 2460066/ 2460067 Fax#91-44-2460645	⑨ Waste load allocation in selected estuaries (Tapi estuary and Ennore creek) is one the components under the Integrated Coastal and Marine Area Management (ICMAM) programme of the Department of Ocean Development ICMAM is conducted with an IDA based credit to the Government of India under the Environmental Capacity Building project of MoEF (waste assimilation capacity of Ennore creek is over) ⑨ Physical oceanographic component of Coastal & Ocean monitoring Predictive System (COMAPS) a long term monitoring program under the Department of Ocean Development ⑨ Identification of suitable locations for disposal of dredge spoil using mathematical models & environmental criteria ⑨ EIA Manual and EIA guidelines for port and harbour projects
31.	National Institute of Oceanography, Goa RO- Mumbai, Kochi	⑨ Coastal Ocean Monitoring and Predictions(COMAP)-Monitoring of coastal waters for physicochemical and biological parameters including petroleum hydrocarbons, trace metals, heavy metals, and biomass of primary (phytoplankton) and secondary (zooplankton, microbial and benthic organisms) ⑨ Marine Biodiversity of selected ecosystem along the West Coast of India

32.	National Botanical Research Institute, Post Box No 436 Rana Pratap Marg Lucknow- 226001, Tel: (+91) 522 271031-35 Fax: (+91) 522 282849, 282881 Lucknow	⑨ Dust filtering potential of common avenue trees and roadside shrubs has been determined, besides studies have also been conducted on heavy-metals accumulation potential of aquatic plants supposedly useful as indicators of heavy metal pollution in water bodies and capable of reducing the toxic metals from water bodies. ⑨ Assessment of bio-diversity of various regions of India
33.	National Geophysical Research Institute, Uppal Road, Hyderabad Telephone:0091-40-7171124, FAX:0091-40-7171564	⑨ Exploration, assessment and management of ground water resources including ground water modelling and pollution studies
34.	National Environmental Engineering Research Institute, Nagpur RO- Mumbai, Delhi, Chennai, Calcutta, Ahmedabad, Cochin, Hyderabad, Kanpur	⑨ National Air Quality Monitoring (NAQM) for CPCB ⑨ Database on cleaner technologies of industrial productions
35.	National Hydrology Institute, Roorkee RO- Belgaum (Hard Rock Regional Centre), Jammu (Western Himalayan Regional Centre), Guwahati (North Eastern Regional Centre), Kakinada (Deltaic Regional Centre), Patna (Ganga Plains North Regional Centre), and Sagar (Ganga Plains South)	⑨ Basin studies, hydrometeorological network improvement, hydrological year book, hydrological modelling, regional flood formulae, reservoir sedimentation studies, environmental hydrology, watershed development studies, tank studies, and drought studies.
36.	National Institute Of Urban Affairs, India Habitat Centre, New Delhi	⑨ Urban Statistics Handbook
37.	National Institute of Occupational Health Meghaninagar, Ahmedabad RO- Banglore, Calcutta	⑨ epidemiological studies and surveillance of hazardous occupations including air pollution, noise pollution, agricultural hazards, industrial hazards in organised sectors as well as small scale industries, carcinogenesis, pesticide toxicology, etc ⑨ WHO collaborative centre for occupational health for South East Asia region and the lead institute for the international programme on chemical safety under IPCS (WHO)
38.	NRSA Data Centre Department of Space, Balanagar, Hyderabad 500 037 Ph- 040-3078560 3078664 sales@nrsa.gov.in	⑨ Satellite data products (raw data, partially processed (radiometrically corrected but geometrically uncorrected), standard data (radiometrically and geometrically corrected), geocoded data(1:50,000 and 1:25000 scale), special data products like mosaiced, merged and extracted) available on photographic (B?W and FCC in form of film of 240 mm X 240mm or enlargements/paper prints in scale varying between 1:1M and 1:12500 and size varying between 240mm and 1000mm) and digital media (CD-ROMs, 8 mm tapes)
39.	Rajiv Gandhi National Drinking Water Mission	⑨ Database for groundwater using remote sensing technology (Regional Remote Sensing Service Centre involved in generation of ground water prospect maps at 1:50,000 scale for the State of Kerala, Karnataka, AP, MP and Rajasthan for RGNDWM)
40.	Space Application Centre Value Added Services Cell (VASC) Remote Sensing Application Area Ahmedabad 380 053 079-676 1188	⑨ National Natural Resource Information System ⑨ Landuse mapping for coastal regulation zone (construction setback line) upto 1:12500 scale ⑨ Inventory of coastal wetlands, coral reefs, mangroves, seaweeds ⑨ Monitoring and condition assessment of protected coastal areas

	Fax- 079-6762735	⑨ Wetland mapping and inventory ⑨ Mapping of potential hotspots and zoning of environmental hazards ⑨ General geological and geomorphological mapping in diverse terrain ⑨ Landslide risk zonation for Tehre area
41.	State Pollution Control Board	⑨ State Air Quality Monitoring Programme ⑨ Inventory of polluting industries ⑨ Identification and authorization of hazardous waste generating industries ⑨ Inventory of biomedical waste generating industries ⑨ Water quality monitoring of water bodies receiving wastewater discharges ⑨ Inventory of air polluting industries ⑨ Industrial air pollution monitoring ⑨ Air consent, water consent, authorization, environment monitoring reports
42.	State Ground Water Board	
43.	Survey of India	⑨ Topographical surveys on 1:250,000 scales, 1:50,000 and 1:25,000 scales ⑨ Digital Cartographical Data Base of topographical maps on scales 1:250,000 and 1:50,000 ⑨ Data generation and its processing for redefinition of Indian Geodetic Datum ⑨ Maintenance of National Tidal Data Centre and receiving/ processing of tidal data of various ports. ⑨ Coastal mapping along the Eastern coast line has been in progress to study the effect of submergence due to rise in sea-level and other natural phenomenon. Ground surveys have been completed for the proposed coastal region and maps are under printing. ⑨ District planning maps containing thematic information (135 maps) have been printed out of 249 maps covering half the districts of India. Districts planning maps for remaining half of the area are being processed by National Atlas and Thematic Mapping Organisation (NATMO)
44.	Town and Country Planning Organisation	⑨ Urban mapping - Thematic maps and graphic database on towns (under progress in association with NRSA and State town planning department)
45.	Wildlife Institute of India Post Bag No. 18, Chandrabani Dehradun - 248 001, Uttaranchal Tel#0135 640111 -15, Fax#0135 640117 email : wii@wii .	⑨ Provide information and advice on specific wildlife management problems. ⑨ National Wildlife Database
46.	Zoological Survey of India Prani Vigyan Bhawan 'M' Block, New Alipore Calcutta - 700 053 Phone # 91-33-4786893, 4783383 Fax # 91-33-786893 RO - Shillong, Pune, Dehradun, Jabalpur, Jodhpur, Chennai, Patna, Hyderabad, Canning, Behrampur, Kozikode, Itanagar, Digha, Port Bliar, Solan	⑨ Red Book for listing of endemic species ⑨ Survey of faunal resources

Annexure VII
Impact Prediction Tools

Table 1: Choice of Models for Impact Prediction: Air Environment

MODEL	APPLICATION	REMARKS	REMARKS FOR DISTILLERY PLANTS APPLICATIONS
ISCST 3	Appropriate for point, area and line sources Application for flat or rolling terrain Transport distance up to 50 km valid Computes for 1 hr to annual averaging periods	Can take up to 99 sources Computes concentration on 600 receptors in Cartesian on polar coordinate system Can take receptor elevation Requires source data, meteorological and receptor data as input.	ISCST3 is appropriate for distillery unit located in both simple terrain, where the terrain features are all lower in elevation than the top of the stack of the source, and in complex terrain, where terrain elevations rise to heights above the stack top. The meteorological data required to run ISCST3 includes mixing heights, wind direction, wind velocity, temperature, atmospheric stability and anemometer height.
AERMOD with AERMET	Settling and dry deposition of particles; Building wake effects (excluding cavity region impacts); Point, area, line, and volume sources; Plume rise as a function of downwind distance; Multiple point, area, line, or volume sources; Limited terrain adjustment; Long-term and short-term averaging modes; Rural or urban modes; Variable receptor grid density; and Actual hourly meteorology data	Can take up to 99 sources Computes concentration on 600 receptors in Cartesian on polar coordinate system Can take receptor elevation Requires source data, meteorological and receptor data as input.	AERMOD, is a state-of-art and steady-state plume dispersion model for assessment of pollutant concentrations from a variety of sources. AERMOD simulates transport and dispersion from multiple points, area, or volume sources based on an up-to-date characterization of the atmospheric boundary layer. Sources may be located in rural or urban areas, and receptors may be located in simple or complex terrain. AERMOD accounts for building near-wake and far-wake effects (i.e., plume downwash) using the PRIME wake effect model. The AERMOD model employs hourly sequential meteorological data to estimate concentrations for averaging times ranging from one hour to one year. The AERMET module is the

MODEL	APPLICATION	REMARKS	REMARKS FOR DISTILLERY PLANTS APPLICATIONS
			meteorological preprocessor for the AERMOD program. Output includes surface meteorological observations and parameters and vertical profiles of several atmospheric parameters. AERMET is a general purpose meteorological preprocessor for organizing available meteorological data into a format suitable for use by the AERMOD air quality dispersion model
PTMAX	Screening model applicable for a single point source Computes maximum concentration and distance of maximum concentration occurrence as a function of wind speed and stability class	Require source characteristics No met data required Used mainly for ambient air monitoring network design	
PTDIS	Screening model applicable for a single point source Computes maximum pollutant concentration and its occurrences for the prevailing meteorological conditions	Require source characteristics Average met data (wind speed, temperature, stability class etc.) required Used mainly to see likely impact of a single source	
MPTER	Appropriate for point, area and line sources applicable for flat or rolling terrain Transport distance up to 50 km valid Computes for 1 hr to annual averaging periods Terrain adjustment is possible	Can take 250 sources Computes concentration at 180 receptors up to 10 km Requires source data, meteorological data and receptor coordinates	

MODEL	APPLICATION	REMARKS	REMARKS FOR DISTILLERY PLANTS APPLICATIONS
CTDM PLUS (Complex Terrain Dispersion Model)	Point source steady state model, can estimate hrly average concentration in isolated hills/ array of hills	Can take maximum 40 Stacks and computes concentration at maximum 400 receptors Does not simulate calm met conditions Hill slopes are assumed not to exceed 15 degrees Requires sources, met and terrain characteristics and receptor details	
UAM (Urban Airshed Model)	3-D grid type numerical simulation model Computes O_3 concentration short term episodic conditions lasting for 1 or 2 days resulting from NOx and VOCs Appropriate for single urban area having significant O_3 problems		
RAM (Rural Airshed Model)	Steady state Gaussian plume model for computing concentration of relatively stable pollutants for 1 hr to 1 day averaging time Application for point and area sources in rural and urban setting	Suitable for flat terrains Transport distance less than 50 km.	
CRESTER	Applicable for single point source either in rural or urban setting Computes highest and second highest concentration for 1hr, 3hr, 24hr and annual averaging times Tabulates 50 highest concentration for entire year for each averaging times	Can take up to 19 Stacks simultaneously at a common site. Unsuitable for cool and high velocity emissions Do not account for tall buildings or topographic features Computes concentration at 180 receptor, circular wing at five downwind ring distance 36 radials	

MODEL	APPLICATION	REMARKS	REMARKS FOR DISTILLERY PLANTS APPLICATIONS
		Require sources, and met data	
OCD (Offshore and coastal Dispersion Model)	It determines the impact of offshore emissions from point sources on the air quality of coastal regions It incorporates overwater plume transport and dispersion as well as changes that occur as the plume crosses the shore line Most suitable for overwater sources shore onshore receptors are below the lowest shore height	Requires source emission data Require hrly met data at offshore and onshore locations like water surface temperature; overwater air temperature; relative humidity etc.	
FDM (Fugitive Dust Model)	Suitable for emissions from fugitive dust sources Source may be point, area or line (up to 121 source) Require particle size classification max. up to 20 sizes Computes concentrations for 1 hr, 3hr, 8hr, 24hr or annual average periods	Require dust source particle sizes Source coordinates for area sources, source height and geographic details Can compute concentration at max. 1200 receptors Require met data (wind direction, speed, Temperature, mixing height and stability class) Model do not include buoyant point sources, hence no plume rise algorithm	
RTDM (Rough Terrain Diffusion Model)	Estimates GLC is complex/rough (or flat) terrain in the vicinity of one or more co-located point sources Transport distance max. up to 15 km to up to 50 km Computes for 1 to 24 hr. or annual ave5rage	Can take up to 35 co-located point sources Require source data and hourly met data Computes concentration at maximum 400 receptors Suitable only for non reactive gases Do not include gravitational effects or depletion	

MODEL	APPLICATION	REMARKS	REMARKS FOR DISTILLERY PLANTS APPLICATIONS
	concentrations	mechanism such as rain/ wash out, dry deposition	
CDM (Climatologically Dispersion Model)	It is a climatologically steady state GPM for determining long term (seasonal or annual) Arithmetic average pollutant concentration at any ground level receptor in an urban area	Suitable for point and area sources in urban region, flat terrain Valid for transport distance less than 50 km Long term averages: One month to one year or longer	
PLUVUE-II (Plume Visibility Model)	Applicable to assess visibility impairment due to pollutants emitted from well defined point sources It is used to calculate visual range reduction and atmospheric discoloration caused by plumes It predicts transport, atmospheric diffusion, chemical, conversion, optical effects, and surface deposition of point source emissions.	Require source characteristics, met data and receptor coordinates & elevation Require atmospheric aerosols (back ground & emitted) characteristics, like density, particle size Require background pollutant concentration of SO_4, NO_3, NOx, NO_2, O_3, SO_2 and deposition velocities of SO_2, NO_2 and aerosols	
MESO-PUFF II (Meso scale Puff Model)	It is a Gaussian, Variable trajectory, puff superposition model designed to account fro spatial and temporal variations in transport, diffusion, chemical transformation and removal mechanism encountered on regional scale. Plume is modeled as a series of discrete puffs and each puff is transported independently Appropriate for point	Can model five pollutants simultaneously (SO2, SO4, NOx, HNO3 and NO3) Require source characteristics Can take 20 point sources or 5 area source For area source – location, effective height, initial puff size, emission is required Computes pollutant concentration at max. 180 discrete receptors and 1600 (40 x 40) grided receptors Require hourly surface data including cloud cover and	

MODEL	APPLICATION	REMARKS	REMARKS FOR DISTILLERY PLANTS APPLICATIONS
	and area sources in urban areas Regional scale model.	twice a day upper air data (pressure, temp, height, wind speed, direction) Do not include gravitational effects or depletion mechanism such as rain/ wash out, dry deposition	

Table 2: Choice of Models for Impact Modeling: Noise Environment

Model	Application
FHWA (Federal Highway Administration)	Noise Impact due to vehicular movement on highways
Dhwani	For predictions of impact due to group of noise sources in the industrial complex (multiple sound sources)
Hemispherical sound wave propagation Air Port	Fore predictive impact due to single noise source For predictive impact of traffic on airport and rail road

Table 3: Choice of Methods for Impact Modeling: Land Environment

Model	Application	Remarks
Digital Analysis Techniques	Provides land use / land cover distribution	
Ranking analysis for soil suitability criteria	Provides suitability criteria for developmental conversation activities	Various parameters viz. depth, texture, slope, erosion status, geomorphology, flooding hazards, GW potential, land use etc. are used.

Table 4: Choice of Models for Impact Modeling: Water Environment

Model	Application	Remarks
QUAL-II E	Wind effect is insignificant, vertical dispersive effects insignificant applicable to streams Data required Deoxygenation coefficients, re-aeration coefficients for carbonaceous, nitrogenous and benthic substances, dissolved oxygen deficit	Steady state or dynamic model
	The model is found excellent to generate water quality parameters Photosynthetic and respiration rate of suspended and attached algae	
	Parameters measured up to 15 component can be simulated in any combination, e.g. ammonia, nitrite, nitrate, phosphorous, carbonaceous BOD, benthic oxygen demand, DO, coliforms, conservative substances and temperature	
DOSAG-3, USEPA: (1-D) RECEIV – II, USEPA	Water quality simulation model for streams & canal A general Water quality model	Steady-state
Explore –I, USEPA	A river basin water quality model	Dynamic, Simple hydrodynamics
HSPE, USEPA	Hydrologic simulation model	Dynamic, Simple hydrodynamics
RECEIVE-II, USEPA	A general dynamic planning model for water quality management	
Stanford watershed model	This model simulates stream flows once historic precipitation data are supplied The major components of the hydrologic cycle are modeled including interception, surface detention, overland inflow, groundwater, evapo-transpiration and routing of channel flows, temperature, TDS, DO, carbonaceous BOD coliforms, algae, zooplanktons, nitrite, nitrate, ammonia, phosphate and conservative substances can be simulated	
Hydrocomp model	Long-term meteorological and wastewater characterization data is used to simulate stream flows and stream water quality	Time dependant (Dynamic)
Stormwater Management model	Runoff is modeled from overland flow, through surface channels, and through sewer network Both combined and separate sewers can be	Time Dependent

Model	Application	Remarks
(SWMM)	modeled. This model also enables to simulate water quality effects to stormwater or combined sewer discharges. This model simulates runoff resulting from individual rainfall events.	
Battelle Reservoir model	Water body is divided into segments along the direction of the flow and each segment is divided into number of horizontal layers. The model is found to generate excellent simulation of temperature and good prediction of water quality parameters. The model simulates temperature, DO, total and benthic BOD, phytoplankton, zooplankton, organic and inorganic nitrogen, phosphorous, coliform bacteria, toxic substances and hydrodynamic conditions.	Two Dimensional multi-segment model
TIDEP (Turbulent diffusion temperature model reservoirs)	Horizontal temperature homogeneity Coefficient of vertical turbulent diffusion constant for charge of area with depth negligible coefficient of thermal exchange constant Data required wind speed, air temperature, air humidity, net incoming radiation, surface water temperature, heat exchange coefficients and vertical turbulent diffusion coefficients.	Steady state model
BIOLAKE	Model estimates potential fish harvest from a take	Steady state model
Estuary models/ estuarial Dynamic model	It is simulates tides, currents, and discharge in shallow, vertically mixed estuaries excited by ocean tides, hydrologic influx, and wind action Tides, currents in estuary are simulated	Dynamic model
Dynamic Water Quality Model	It simulates the mass transport of either conservative or non-conservative quality constituents utilizing information derived from the hydrodynamic model Bay-Delta model is the programme generally used. Up to 10 independent quality parameters of either conservative or non-conservative type plus the BOD-DO coupled relationship can be handled	Dynamic model
HEC -2	To compute water surface profiles for stead7y, gradually: varying flow in both prismatic & non- prismatic channels	
SMS	Lake circulation, salt water intrusion, surface water profile simulation model	Surface water Modeling system

Model	Application	Remarks
		Hydrodynamic model
RMA2	To compute flow velocities and water surface elevations	Hydrodynamic analysis model
RMA4	Solves advective-diffusion equations to model up to six non-interacting constituents	Constituent transport model
SED2D-WES	Model simulates transport of sediment	Sediment transport model
HIVEL2D	Model supports subcritical and supercritical flow analysis	A 2-dimensional hydrodynamic model
MIKE-II, DHI	Model supports, simulations of flows, water quality, and sediment transport in estuaries, rives, irrigation systems, channels & other water bodies	Professional Engineering software package

Table 5: Choice of Methods for Impact Modeling: Biological Environment

Name	Relevance	Applications	Remarks
Flora			
Sample plot methods	Density and relative density Density and relative dominance	Average number of individuals species per unit area Relative degree to which a species predominates a community by its sheer numbers, size bulk or biomass	The quadrant sampling technique is applicable in all types of plant communities and for the study of submerged, sessile (attached at the base) or sedentary plants
	Frequency and relative frequency importance value	Plant dispersion over an area or within a community	Commonly accepted plot size: 0.1 m^2- mosses, lichens & other mat-like plants
		Average of relative density, relative dominance and relative frequency	0.1 m^2- herbaceous vegetation including grasses
			10.20 m^2 – for shrubs and saplings up to 3m tall, and
			100 m^2 – for tree communities
Transects & line intercepts methods	Cover	Ratio of total amount of line intercepted by each species and total length of the line intercept given its cover	This methods allows for rapid assessment of vegetation transition zones, and requires minimum time or equipment of establish
	Relative dominance	It is the ratio of total individuals of a species and total individuals of all species	Two or more vegetation strata can be sampled simultaneously
Plot-less sampling methods	Mean point plant Mean area per plant	Mean point – plant distance Mean area per plant	Vegetation measurements are determined from points rather than being determined in an area with boundaries
	Density and relative density		Method is used in grass-land and open shrub and tree communities
	Dominance and relative dominance		It allows more rapid and extensive sampling than the plot method
	Importance		Point- quarter method is

Name	Relevance	Applications	Remarks
	value		commonly used in woods and forests.
Fauna			
Species list methods	Animal species list	List of animal communities observed directly	Animal species lists present common and scientific names of the species involved so that the faunal resources of the area are catalogued
Direct Contact Methods	Animal species list	List of animals communities observed directly	This method involves collection, study and release of animals
Count indices methods (Roadside and aerial count methods)	Drive counts Temporal counts	Observation of animals by driving them past trained observers	Count indices provide estimates of animal populations and are obtained from signs, calls or trailside counts or roadside counts
	Call counts	Count of all animals passing a fixed point during some stated interval of time	These estimates, through they do not provide absolute population numbers, Provide an index of the various species in an area
			Such indices allow comparisons through the seasons or between sites or habitats
Removal methods	Population size	Number of species captured	Removal methods are used to obtain population estimates of small mammals, such as, rodents through baited snap traps
Market capture methods	Population size estimate (M)	Number of species originally marked (T) Number of marked animals recaptured (t) and total number of animals captured during census (n) N = nT/t	It involves capturing a portion of the population and at some later date sampling the ratio of marked to total animals caught in the population

Table 6: Choice of Methods for Impact Predictions: Biological Environment

Relevance		
Name	**Application**	**Remarks**
Extrapolative Methods	A prediction is made that is consistent with past and present socio-economic data, e.g. a prediction based on the linear extrapolation of current trends	
Intuitive Forecasting (Delphi techniques)	Delphi technique is used to determine environmental priorities and also to make intuitive predictions through the process of achieving group consensus	Conjecture Brainstorming Heuristic programming Delphi consensus
Trend extrapolation and correlation	Predictions may be obtained by extrapolating present trends Not an accurate method of making socio-economic forecasts, because a time series cannot be interpreted or extrapolated very far into the future with out some knowledge of the underlying physical, biological, and social factors	Trend breakthrough precursor events correlation and regression
Metaphors and analogies	The experience gained else where is used to predict the socio-economic impacts	Growth historical simulation commonsense forecasts
Scenarios	Scenarios are common-sense forecasts of data. Each scenario is logically constructed on model of a potential future for which the degrees of "confidence" as to progression and outcome remain undefined	Common-sense
Dynamic modeling (Input-Out model)	Model predicts net economic gain to the society after considering all inputs required for conversion of raw materials along with cost of finished product	
Normative Methods	Desired socio-economic goals are specified and an attempt is made to project the social environment backward in time to the present to examine whether existing or planned resources and environmental programmes are adequate to meet the goals	Morphological analysis technology scanning contextual mapping - functional array - graphic method Mission networks and functional arrays decision trees & relevance trees matrix methods scenarios

REFERENCES

Reference Documents

- ***Ministry of Environment and Forest, GoI*** - "Environment Impact Assessment Notification" S.O.1533 dated 14th September 2006.
- ***Ministry of Environment and Forest, GoI*** – "Environment Impact Assessment Notification 2006 – Amendment" S.O. 195 (E) dated 19th January 2009.
- ***Ministry of Environment and Forest, GoI*** – Charter on Corporate Responsibility for Environment Protection Action Points for 17 Categories of Industries, CPCB, March 2003.
- ***Larry W. Canter,*** "Environmental Impact Assessment", Second Edition, McGraw Hill, University of Oklahoma, 1997.
- ***International Finance Corporation (IFC)*** – "Environmental, Health and Safety Guidelines, Offshore Oil and Gas Development", World Bank Group, April 30, 2007.
- ***International Finance Corporation (IFC)*** - "Environmental, Health and Safety Guidelines, Onshore Oil and Gas Development, World Bank Group, April 30, 2007.
- ***International Association for Impact Assessment*** in Cooperation with Institute of Environmental Assessment, UK – "Principles of Environmental Impact Assessment Best Practice, 1996
- ***USEPA*** - "Sector Handbook on Oil & Gas Extraction", October, 2000.
- ***World Bank Group*** - "Pollution Prevention and Abatement Handbook on Oil & Gas Development (Onshore)", July 1998.
- "Environmental Management of Offshore Oil Development and Maritime Oil Transport, A background document for stakeholders of the West African Marine Eco Region by Sandra Kloff and Clive Wicks, ***Members of CEESP*** (IUCN Commission on Environmental, Economic and Social Policy), October 2004.
- "Environmental Management in Oil and Gas Exploration and Production, An Overview of Issues and Management Approaches", ***Joint E&P Forum/UNEP Technical Publication***, 1997.
- ***Ecosmart India Ltd.,*** - Report on Secondary Data Collection for Environmental Information Centre, submitted to Ministry of Environment and Forests, 28th March 2003

Referred Websites

- http://envfor.nic.in/divisions/iass/eia.htm
- http://petroleum.nic.in/
- http://www.cpcb.nic.in/
- http://www.dghindia.org/site/index.aspx
- http://www.industry.siemens.com/oilgas/en/processes/upstream/offshore/exploration.htm
- http://www.iaia.org
- http://www.ogp.org.uk/
- http://www.oil-india.com/

IL&FS Ecosmart Limited
Flat # 408, Saptagiri Towers
Begumpet
Hyderabad – 500 016
Ph: + 91 40 40163016
Fax: + 91 40 40032220
For any queries or technical inputs kindly mail:
sateesh.babu@ilfsecosmart.com
suman.thomas@ilfsecosmart.com