Environmental Impact Assessment Study
for the Proposed Quality Improvement Project from BS-IV to BS-VI grade

Project Proponent

MATHURA REFINERY

of

INDIAN OIL CORPORATION LIMITED

at Village Bhainsa, District Mathura, Uttar Pradesh

JUNE 2017

Project Consultant

Cholamandalam MS Risk Services Limited

Accredited EIA Consulting Organization
Certificate No: NABET/EIA/1 011/011
Parry House, 4th Floor, No:2, NSC Bose Road,
Parrys, Chennai – 600 001

DECLARATION BY PROJECT PROPONENT

Indian Oil Corporation Limited (IOCL), Mathura has conducted the "Environmental Impact Assessment Study for Proposed Quality Improvement Project from BS-IV to BS-VI grade, Bhainsa village, Mathura Tehsil, Mathura District, Uttar Pradesh.

The EIA report preparation have been undertaken in compliance with the Terms of Reference (ToR) issued by MoEF & CC. Information and content provided in the report is factually correct for the purpose and objective for such study undertaken.

We hereby declare the ownership of contents (information and data) of EIA/EMP Report.

For on behalf of Indian Oil Corporation Limited (IOCL), Mathura.

Signature:

Name: SUNIL KAPOOR

Designation: General Manager (HSE)

Date: 22.06.17

DECLARATION BY EIA CONSULTANT

This EIA report has been prepared by ***Cholamandalam MS Risk Services Limited (CMSRSL)****, in line with EIA Notification, dated 14th September 2006, seeking prior Environmental Clearance from the Ministry of Environment, Forests and Climate Change, New Delhi.*

This work has been undertaken in accordance with ***ISO 9001:2008 Quality Management System*** *with all reasonable skill, care and diligence within the terms of the contract with the client, incorporating our General Terms & Conditions of Business and taking account of the resources devoted to it by agreement with the client.*

We disclaim any responsibility to the client and others in respect of any matters outside the scope of the above.

Further, this report is confidential to the client and the use of this report by unauthorized third parties without written authorization from CMSRSL shall be at their own risk.

For and on behalf of ***Cholamandalam MS Risk Services Limited***

Approved by : N.V.Subba Rao

Sign : 

Designation : Chief Executive

Date : 22nd June 2017

PROJECT DECLARATION BY EIA CONSULTANT ORGANIZATION

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

Sector as per NABET Scheme	10	Petroleum Refining Industry
Sector as per EIA Notification	4(a)	Petroleum refining industry

EIA Coordinator:

Name : V.S.Bhaskar

Signature :

Date : 22nd June 2017

Period of Involvement : April 2016 to till date

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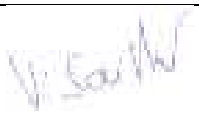
Functional Area Experts:

S.No.	Functional Areas	Name of the Expert/s	Involvement (Period and Task)	Signature
1	AP- Air Pollution Prevention, Monitoring & Control	Mr. V S Bhaskar	April 2016 to till date Task: Site visit, design of Ambient air quality monitoring network, evaluation of result of ambient air quality monitoring, inferring baseline data collected, identification of potential impact to air quality during construction and operation phase, developing and finalizing EMP to minimize impact to air quality.	
2	AQ- Meteorology, Air Quality Modeling & Prediction	Mr. V S Bhaskar	April 2016 to till date Task: Supervision of air quality modeling and identification of impacts due to proposed expansion. Finalization of mitigation measures with client.	

S.No.	Functional Areas	Name of the Expert/s	Involvement (Period and Task)	Signature
3	WP- Water Pollution Monitoring Prevention & Control	Mr. V S Bhaskar	April 2016 to till date Task: Site visit, Finalization of sampling locations, finalizing water balance for the project, inference of baseline data collected identification of impacts and preparation of mitigation plan.	
4	SHW- Solid and Hazardous Waste Management	Mr. Ravishankar D	April 2016 to till date Task: Identification of solid waste to be generated from the process and suggesting mitigation plan.	
5	MSW – Municipal Solid Waste	Ms. Sathya.S	April 2016 to till date Task: Identification of solid waste to be generated from the process and suggesting mitigation plan and coordination with EIA coordinator & functional area expert in report writing	
6	SE- Socio-Economic Aspects	Mr. Karthick C S	April 2016 to till date Task: Undertaking primary socio-economic survey, identification of social impact due to proposed project, preparation of mitigation plan, development of CSR plan.	
8	EB- Ecology and Biodiversity	Dr. T. Balakrishna	April 2016 to till date Task: Field survey. Impact prediction and suggesting mitigation measures. Preparation of ecology management plan.	
9	LU- Land Use	T.P.Natesan	April 2016 to till date Task: Preparation of land use land cover maps for the study area using GIS/ related tools followed by ground truth verification.	
10	HG- Hydrology Ground Water & Water Conservation GEO- Geology	T.P.Natesan	April 2016 to till date Task: Aquifer details, groundwater potential, determination of ground use pattern, Study of local hydro-geology, development of	

S.No.	Functional Areas	Name of the Expert/s	Involvement (Period and Task)	Signature
			rainwater harvesting program, preparation of contour map for the study area and estimation of groundwater direction.	
11	RH- Risk & Hazard Management	Mr. V S Bhaskar	April 2016 to till date Task: Identification of risk due to storage of fuel and raw materials, interpreting consequence contours, suggesting risk mitigation measures.	

Associate Functional Area Experts involved:

1. Mr. Srikanth .G – AFAE – AP & WP
2. Mr. Mahendra B. - Team member
3. Ms. Sujatha Gurudev - Team Member

Declaration by the Head of the Accredited Consultant Organization/ Authorized Person

I, N.V.Subbarao, hereby, confirm that the above mentioned experts prepared the EIA Report for the "Environmental Impact Assessment Study for the Proposed Quality Improvement Project from BS-IV to BS VI grade".

I also confirm that the consultant organization shall be fully accountable for any misleading information mentioned in this statement.

Signature: 

Name : N V Subbarao

Name of the EIA Consultant Organization :M/s.Cholamandalam MS Risk Services Limited

NABET Certificate No. : NABET/EIA/1316/RA009 & Extension Letter No. QCI/NABET/EIA/ACO/16/12/0224 dated, 2nd December 2016.

Executive Summary

1. Introduction

Indian Oil Corporation Limited (IOCL) is India's largest commercial enterprise engaging in the business of refining, pipeline transportation, marketing of petroleum products and also involving in exploration & production of crude oil & gas, marketing of natural gas and petrochemicals. IOCL accounts for nearly half of India's petroleum products market share owning 10 refineries. It is the sixth refinery of IOCL that was commissioned in 1982 with a capacity of 6.0 MMTPA to meet the demand of petroleum products in North Western region of the country. The major secondary processing units provided were Fluidized Catalytic Cracking Unit (FCCU), Vis-breaker Unit (VBU) and Bitumen Blowing Unit (BBU).

The existing project site is located at Survey No 272, Bhainsa village, Mathura Tehsil, Mathura District, Uttar Pradesh and is location is projected in the Figure 1.1. The study area is covered by Toposheet No. 54 E11 and 54 E15. The vicinity map of the IOCL Mathura Refinery is presented in the Figure 1.2.The Propose project falls under Taj Trapezium Zone, the contribution of Indian Oil's Mathura Refinery for conserving Environment and Ecology in Taj Trapezium Zone by adopting Environmental friendly technologies is acknowledged and a commemorative corporate my stamp of Mathura Refinery will be released very soon.

Presently, the following are the major streams produced from various process units of Mathura refinery are blended in different proportions to produce the Motor Spirit (MS):

a) Isomerate from PENEX Unit
b) Treated Gasoline from Prime G Unit
c) Heavy Reformate from Catalytic Reforming Unit

Both Isomerate and Heavy Reformate streams of MS are almost free of any sulphur content. However, sulphur content of Gasoline remains around 100 ppmw . As current sulphur specification of MS of BS-IV specification is 50 ppmw, hence, Mathura Refiney is currently able to produce the MS meeting BS-IV specifications by blending all above specified MS Streams.

Similarly, the following are the major streams produced from various process units of Mathura refinery are blended in different proportions to make High Speed Diesel (HSD) complying the BS-IV specifications:

d) Diesel from Hydro Cracker Unit (OHCU)

e) Diesel from Diesel Hydro Desulphurization Units (DHDS)

f) Diesel from Diesel Hydro Treatment Unit (DHDT)

Both diesel streams produced from OHCU and DHDT contain the sulphur of around 10 ppmw. However, sulphur content of diesel stream produced from DHDS remains around 50 ppmw. As current sulphur specification of HSD complying the BS-IV norms is 50 ppmw, hence, Mathura Refinery is currently able to produce the HSD meeting BS-IV specifications by blending all above mentioned diesel Streams.

As per the Auto Fuel Quality Vision Policy 2025 and communication by MoP&NG on 22nd May'15, it has been directed to implement BS-VI grade fuel in the entire country w.e.f. 1st April 2020. For sustaining the operations of Mathura Refinery, the existing facilities must be upgraded to generate BS-VI grade fuels from 2020 onwards.

The proposed project is for the Quality Improvement Project (QIP) from BS-IV to BS-VI grade at the same crude processing capacity of 8 MMTPA to reduce sulphur content to 10 ppm without increasing the production capacities in the existing refinery. However, there will be only minor modification of few processes in the existing refinery.

Salient features of the study area are presented in Table 1. It can be noted that there are no notified ecological and wildlife sanctuaries within 10Km radius.

Table **1** Salient Features of the Study Area

S. No.	Particulars	Details
1.	Location	IOCL Mathura Refinery
	Plot/ Survey/Khasra No.	272
	Village	Bhainsa village
	Tehsil	Mathura
	District	Mathura District
	State	Uttar Pradesh
2.	Latitude	27°22'09.15''N to 27°23'32.52''N
3.	Longitude	77° 41'03.69''E to 77°41'53.47''E
4.	Elevation above Mean Sea Level	174 m

S. No.	Particulars	Details
5.	Climatic conditions (Annual as per IMD-Mathura)	Annual Mean Max Temp: 44.5^{0}C Annual Mean Min Temp: 2.5^{0}C Annual Mean Rainfall: 633.3 mm Predominant Wind Direction (Blow from): North-West
6.	Site specific Climatological data	Maximum Temperature: 37^{0}C Minimum Temperature: 6^{0}C Predominant wind direction(Blow from): North-west
7.	Nearest Highway	• National Highway (NH-2) passing adjoining to the plant Eastern boundary • SH-33, 5 km Northwestern side
8.	Nearest Railway station	• Baad Railway Station at 2 km from project site in Northern direction • Mathura Railway Junction is 10.3 km towards North
9.	Nearest Air Port	Indira Gandhi International Airport at Delhi, 140 km away from plant boundary towards North
10.	Nearest Town	Mathura, 11.8 km, Northern direction from project side
11.	Interstate/National Boundaries	Rajasthan state boundary located at distance of 7.5 km towards western direction from the project site boundary.
12.	Reserve Forest	Baad R.F, 2 km towards Northern side
13.	Ecologically sensitive zones	No ecologically and archeologically sensitive places are located within 10 km radius of the project site
14.	Archaeological monuments	Project site is located within the geographical limits of Taj Trapezium Zone
15.	Water bodies	Yamuna River flowing at about 6 Km towards Eastern side
17	Defense Installations	Nil within 10 km radius
18	Seismic Zone	Seismic Zone IV as per IS: 1893 (Part-1)-2002

The industry has obtained CTO vide no. F73255/C-4/Vayu Pradushan -26/16 under Air (Prevention and Control of Pollution) Act, 1981 and CTO vide no. F-73256/C-4/Jal Pradushan-42/2016 under Water (Prevention and Control of Pollution) Act, 1974. The validity of the consent is 31.12.2017. The industry is regularly submitting the Environmental compliance of EC conditions report to Regional Office of MoEF.

Figure 1-1 Location of the Project Site

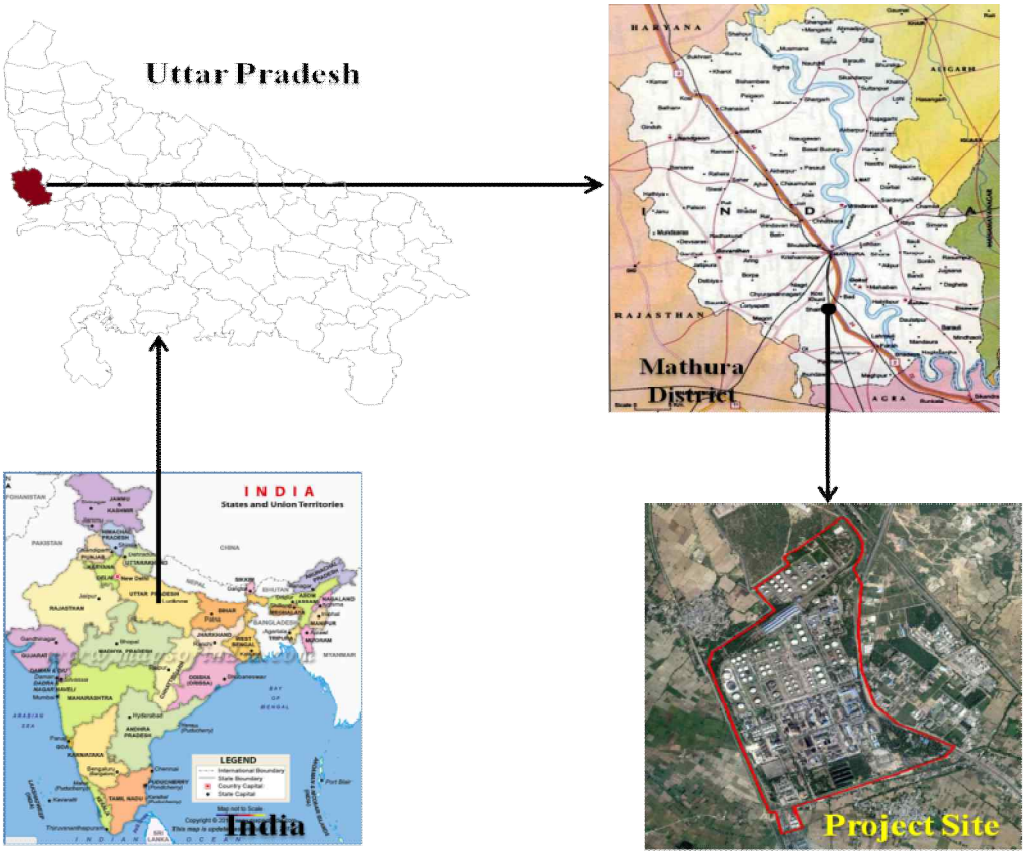
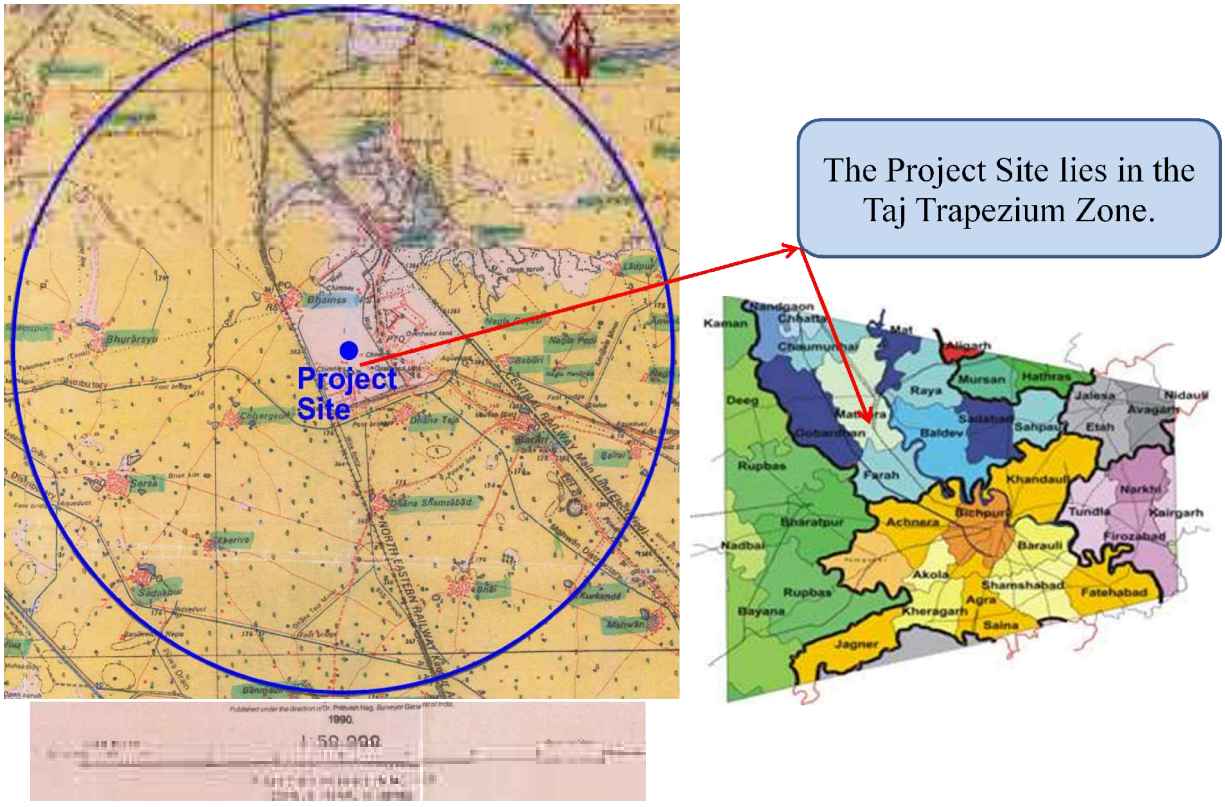


Figure 1-2 Toposheet showing the 10Km radius of the Existing Facility



1.1. Need for Environment Clearance

According to the Environmental Impact Assessment Notification 2006, issued by Ministry of Environment, Forests and Climate Change (MoEF & CC) under Environment Protection Act all developmental projects of Petroleum refining industry should undertake Environmental Impact Assessment Study (EIA) and obtain necessary Environmental Clearance from relevant authorities.

Since the proposed quality improvement project falls under category "A" under sector 4(a) of the EIA Notification 2006. In this context, IOCL has conducted EIA study to obtain Environmental Clearance for the proposed Quality Improvement Project.

1.2. Environmental Impact Assessment Study

The project was appraised by Reconstituted Expert Appraisal Committee (Industry-2), Ministry of Environment and Forest (MoEF&CC) during the 11th Expert Appraisal Committee meeting held on 20-21th July 2016 and the project was accorded Terms of Reference (ToR) vide File no. J-11011/151/2016-IA II (I) dated 23rd September 2016. As per the approved ToR, the Public Hearing for the proposed Quality Improvement Project was exempted as under 7 (ii) of the EIA Notification, 2006. This EIA study was undertaken by M/s. Cholamandalam MS Risk Services, an NABET accredited EIA consulting organisation, with specific project related inputs required for undertaking the EIA studies from the project department of M/s. Mathura Refinery, Indian Oil Corporation Ltd. M/s Cholamandalam MS Risk Services is authorized to undertake EIA studies for Petroleum Refinery plant as per the NABET accreditation scheme. The environmental impact assessment study team headed by an accredited EIA Coordinator, along with the approved Functional Area Experts has undertaken detailed baseline studied between 25th November 2016 and 23rd February 2017 to represent the Post monsoon conditions (Winter Season). Various physiochemical parameters such as meteorology, air quality, water quality, noise level recording, and soil quality studies around the radius of 10 kms from existing plant were undertaken by MoEF and NABL accredited testing agency. Various specialized studies such as hydro-geological studies, socioeconomic survey, ecological and biological survey etc were undertaken by the respective experts. Based on the project inputs provided by Mathura Refinery with regards to the material, energy and water balance etc a detailed environmental impact

assessment study was undertaken using qualitative and quantitative methods, wherever applicable. The adequacy of the risk mitigation measures considered in the pre-feasibility report provided by Mathura Refinery was evaluated and, the residual environmental risks if any have been evaluated. Additional environmental risk control measures, wherever applicable were suggested.

2. Environmental Management in the Existing Facility of Mathura Refinery

At Mathura Refinery, technology and ecology go hand in hand with continuous endeavour for Product Quality up-gradation, Energy Conservation and Environment Protection. Mathura Refinery is the first in Asia and third in the world to receive the coveted ISO-14001 certification for Environment Management System in 1996. It is also first in the world to get OHSMS certification for Safety Management in 1998.

The quantities and the composition of the gaseous, liquid and solid waste that are generated in the plant will be regulated such that their final disposal into the environment meets all the statutory requirements and the environmental impacts are minimised. By adopting the processes for the removal of sulphur from streams used to blend the finished products. This sulphur is normally recovered as elemental sulphur. The total sulphur input to the refinery and output from the refinery is 145053.2 MT with the total SO_2 emission of 339.8 Kg/hr.

IOCL, Mathura is equipped with three Claus reactors and one Super Claus reactor each of 4x60 TPD. 180TPD of tail gas treating unit using Reduction Absorption Recycle (RAR) process is used for recovery of Sulphur form tail gasses streams from SRU.

IOCL has adopted leak detection and repair programs as per the consent conditions. VOC emissions are periodically measured in each of the production department to establish the emissions from pumps, compressors, valves and glands. Plant records confirmed that the overall VOC emissions were found to comply with stipulated fugitive VOC emission discharge standards. Online emission monitoring systems were installed on all plant process stacks. Similarly continuous ambient air quality monitoring stations are installed as per the UPPCB directions and the criteria pollutants of concern are being monitored. A dedicated environment team headed by General Manager-Health, safety and environment is supported by a team of engineers to implement various HSE

related programs in the facility. A dedicated CSR team is implementing various community development and CSR activities in the region.

IOCL, Mathura is having a full-fledged effluent treatment plant system for maintaining CPCB discharge standards. The Effluent Treatment Plant is capable of handling 1050m^3/hr to accommodate peak flows in during the wet season. Large quantities of treated wastewater are being recycled in the existing facility as a part of the environment management initiatives. The discharge of treated water into the river is decreasing from 176m^3/hr to 169m^3/hr for proposed project.

The refinery is in the practice of disposing residual oily sludge through bio remediation technology developed by IOC- R&D. Facility also obtains Hazardous waste consent from UPPCB. IOCL, Mathura is already practicing a safe storage facility for disposal of Hazardous waste in environment friendly disposal methods like bioremediation, metal recovery from spent catalyst, etc. Massive afforestation activities have been undertaken by Mathura Refinery. Besides serving as a population sink, this green cover also enhances the aesthetic look. Mathura refinery has planted 1, 79,189 tress in the surroundings area including refinery & township. About 1, 15,000 trees are planted in the Agra region around Taj Mahal.

An ecological park has been developed within the refinery premises. As per the plant records, Tree plantation in the ecological park was done under the guidance of Mr. D.N. Rao, an eminent Professor of the Banaras Hindu University. Mathura Refinery has implemented 14 numbers of Rain Water Harvesting facilities inside the refinery premises and Township.

3. Baseline Environmental Conditions

Mathura district is a city in the North Indian state of Uttar Pradesh. It is situated along the banks of the river Yamuna is a district of Uttar Pradesh state of northern India. The historic town of Mathura is the district headquarters. Mathura reaches mean maximum temperature to 45.4°C during the summer months, especially in June, whereas the lowest temperature reported during the winter season (December, January month) was in the order of 2.8°C during January. According to the data published by Indian Meteorological Department (IMD Met data Handbook), the maximum number of rainy days was found during August, and the average yearly rainfall for the study area was

reported to be 633.3 mm with 36.5 rainy days. The annual windrose indicates that nearly 28% time winds predominantly blow from North-West direction. During the winter period, nearly 28% of time winds predominantly blow from North-West direction. During the summer period, nearly 33% of time winds predominantly blow from North-West direction. Baseline studies indicated that the average concentrations of air pollutants such as PM_{10}, $PM_{2.5}$, SO_2 and NO_x in the study area were found to be in the range of 79.5µg/m^3 to 92µg/m^3, 47.4µg/m^3 to 51.2 µg/m^3, 10.7 µg/m^3 to 14.9 µg/m^3, and 20.6 µg/m^3 to 23.6 µg/m^3 respectively. These values are comparable with that of the monitoring data reported by Uttar Pradesh Pollution Control Board (UPPCB), which are within the limits of National Ambient Air Quality Standards (NAAQs). Data pertaining to the continuous ambient air monitoring stations at the existing facility indicated that the stipulated criteria pollutants are well within the NAAQs.

Noise levels at the facility boundary were reported average day time and night time noise levels at residential areas in the study area was found to be varying from 44.8 dB (A) to 58.7 dB (A) and 39.1 dB(A) to 53.9 dB(A) respectively. Noise level at industrial area i.e. IOCL refinery plant, it was found to be 58.7 dB(A) during day time and 52.4 dB (A) during night time which is within the CPCB limits for industrial areas. Soil samples collected from the study area confirmed that the samples are free from any toxic contamination and organic carbon was found in the range of 1.8 % to 2.3% which is very low for supporting vegetation. Ground water quality data indicated that the average pH ranges in between 7.1 to 7.87, TDS ranges from 1028 mg/l to 1992 mg/l, TDS in the Project site is 1643 mg/l. Total hardness is in the range of 92 mg/l to 804 mg/l which is also higher than the desirable limit. The heavy metal concentration is Below Detectable Limit in all sampled locations and well within the standards for drinking water as per IS: 10500 –1991 “Specification for drinking Water” for ground water. Fluorides concentrations are in the ranges of 0.22 mg/l to 0.28 mg/l which are found within the drinking water standards.

Reserve Forest (RF) is situated towards Northern side at distance of 2 Kms. In the buffer zone of study area at Baad and Kurkunda villages approximately 36.7 Ha and 9.08 Ha were categorized as Reserve Forests. The green patches of land were dominated by exotic alien species the *Prosopis juliflora and* stunted growth of *Casuarina* and shrubs like *Cassia auriculata* were observed. This forest area inhabited by snakes, Wild pig and

Monkey was observed. Natural forests are absent in the study area. There is another reserved forest - Farah-Salempur Reserved forests, which is about 17 km from the refinery and covers an area of 87.04Ha.

4. Environmental Impacts and Management Program

The construction activities of new installation will not necessitate any land acquisition and it is within existing facility. Hence, Rehabilitation and Resettlement (R&R) regulations are not applicable. The possible impacts due to the proposed upgrades will be due to increased emissions from the revamps of existing DHDS, Prime G and installation of new CCR, and ISOM units.

Air quality modelling was undertaken using ISCST3 modelling system to assess the possible increase in ground level concentrations of PM_{10}, SO_2 and NO_x from the proposed activities. The peak predicted ground level concentrations of the PM_{10}, SO_2 and NO_x were estimated as 0.15µg/m^3, 0.27µg/m^3 and 1.87µg/m^3 respectively. Due to adoption of efficient pollution control systems, the peak predicted ground level concentrations would occur within existing plant sources. Hence the resultant post project scenario (baseline plus predicted increase) of pollutant concentration in the ambient air will be within the NAAQs. The fresh water requirement of existing facility is 669m^3/hr and same will be maintained for the proposed project QIP. Additional water required for the QIP is 11m^3/hr which is met from the recycling of treated effluent. No additional water is sourced / required for the proposed QIP and there will be no impact on fresh water resources. The treated recycled water is increased from 402 m^3/hr to 413 m^3/hr. Due to increasing of treated recycled water, waste water discharge is decreased from the 176m^3/hr to 169m^3/hr to the river. The impact of waste water discharge to the river after proposed project will be less.

IOCL has considered installing low noise generating equipment wherever applicable as per the recommended standards and guidelines. Some of the major noise generating equipment will be housed inside the room with an average wall thickness of 230 mm to attenuate noise emissions. According to the Noise Control Handbook (ref)[1], a 230 mm

[1] *Acoustics and Noise Control Handbook for Architects and Builders, Leland K. Irvine Roy L. Richards*

brick wall will provide a noise reduction level of about 20 dB(A) to 25 dB(A) across the wall.

The impact on land environment during operational phase shall be due to disposal of solid and hazardous waste generated during operation. There shall be marginal additional generation of spent catalysts from proposed process units. The oily sludge generated from new tanks shall be disposed along with the existing sludge, posing no major impact on land environment. The solid waste (hazardous/ non hazardous) generated during this phase shall be disposed to identified authorized disposal agency.

In addition to the existing pollution control systems and environmental management program of the existing facility, the management of Mathura refinery has proposed to invest additionally Rs.260.05 Lacs towards various pollution control and environmental management programs under the proposed project.

5. Project Cost and Implementation Schedules

The estimated project cost of the Existing Revamps and new installations will be in the order of Rs. 1713 Crores. Out of the above mentioned capital cost, about Rs. 260.05 lakhs has been budgeted towards environmental management programs like Monitoring activities, Bioremediation, tree plantation and study jobs etc.

6. Conclusions

Based independent assessment on the baseline environmental status and also prediction of impacts the following conclusions.

- This project will have beneficial effects in terms of growth and development of the regional economy
- This project will also generate direct and indirect employment to a considerable number of families, who will render their services for the employees of the project
- The proposed project is structured to be in line with the requirements of MoEF/CPCB/ PCB.
- Wastewater treatment facilities and high efficiency pollution abatement measures will result in minimising the adverse impacts on the environment

Thus, it can be concluded that with the judicious and proper implementation of the pollution control and mitigation measures, the proposed project can proceed without any significant negative impact on the environment.

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1. INTRODUCTION

1.1. Overview of Indian Oil Corporation Limited

Indian Oil Corporation Limited (IOCL) is India's largest commercial enterprise engaging in the business of refining, pipeline transportation, marketing of petroleum products and also involving in exploration & production of crude oil & gas, marketing of natural gas and petrochemicals. IOCL accounts for nearly half of India's petroleum products market share owning 10 refineries.

Mathura Refinery is located at Survey No 272, Bhainsa village, Mathura Tehsil, Mathura District, Uttar Pradesh. It is the sixth refinery of IOCL that was commissioned in 1982 with a capacity of 6.0 MMTPA to meet the demand of petroleum products in North Western region of the country. The major secondary processing units provided were Fluidized Catalytic Cracking Unit (FCCU), Vis-breaker Unit (VBU) and Bitumen Blowing Unit (BBU). In the year 1998 Continuous Catalytic Reforming Unit (CCRU) was commissioned for the production of unleaded Gasoline and in the following year a Diesel Hydro Desulphurisation Unit (DHDS) was commissioned for the production of High Speed Diesel (HSD) with a low Sulphur content of 0.25% wt (max). The capacity of the refinery increased to 8 MMTPA in the year 2000 with the commissioning of once through Hydrocracker Unit. Diesel Hydro-Treating Unit (DHDT) and MS Quality Up-gradation Unit (MSQU) were installed in 2005 for production of Euro-III grade HSD & MS as per Auto Fuel Policy of Govt. of India. FCC Gasoline Desulphurization Unit (PRIME-G) was commissioned in 2010 and since then the supply of Euro-IV grade MS and HSD started on a continuous basis.

Mathura Refinery has continuously been upgrading its technology in consideration with product quality, energy conservation and environment protection. The refinery is having its own captive power plant which was augmented with the commissioning of three Gas Turbines (GT) and Heat Recovery Steam Generator (HRSG) in phases from 1997 to 2005 using Natural Gas (NG) as fuel. For upgrading environmental standards, old Sulphur Recovery Units (SRU) was being replaced with new Sulphur Recovery Units with 99.9 % recovery in the year 1999. Additional Sulphur Recovery Unit was also installed in June 2011 as a hot standby.

All Indian oil refineries fully comply with the prescribed environmental standards and sustained efforts are being made to further improve the standards by introducing new state of the art technologies to further improve the existing standards and facilities. The environmental management systems of the refinery are certified to ISO-14001 standards. The refinery is accredited for Occupational Health & Safety Assessment Series (OSHAS-18001).

1.2. Awards and Accolades

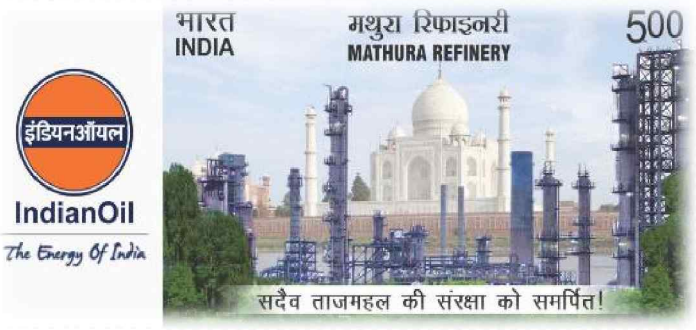
Mathura Refinery has been adjudged by CHT as the Winner of Jawaharlal Nehru Centenary Awards for Energy Performance of Refineries in Group – 1 for achieving lowest MBN during 2014-15. The award was handed over during the 20th RTM held at Gandhinagar on 7th Sep'16.

Mathura Refinery won the 1st prize for Implementation of City Official Language for the year 2015-16. Refinery received this award for fourth consecutive year. The award was given by President of India at Rashtrapati Bhawan on 14th September, 2016, New Delhi.

Mathura Refinery has been conferred with "Safety Innovation Award 2016" by The Institution of Engineers, Delhi State Centre for outstanding efforts and performance in the field of Safety on 9th Nov'16.

Acknowledging the contribution of Indian Oil's Mathura Refinery for

conserving Environment and Ecology in Taj Trapezium Zone by adopting Environment Friendly technologies, a commemorative corporate my stamp of Mathura Refinery will be released very soon.



1.3. Proposed Quality Improvement Project

Presently, Mathura Refinery is operating with a capacity of 8 MMTPA producing 100 % Motor Spirit (MS) and High Speed Diesel (HSD) complying BS-IV specifications. The proposed Quality Improvement Project (QIP) is a modernization project to upgrade the quality of MS and HSD from BS-IV grade to BS- VI grade as per the Auto Fuel Quality Vision Policy 2025 and communication by MoP & NG on 22nd May 2015.

In order to produce BS-VI grade fuels it is necessary to adopt suitable technologies and thus Mathura Refinery has considered revamp of its existing Diesel Hydro Desulphurisation (DHDS) and Prime-G (Gasoline Desulphurization) apart from the addition of new CCR (Catalytic Reformer) and isomerisation units. New Continuous CCR of capacity 400 TMTPA and ISOM unit of capacity 200 TMTPA have been proposed to convert excess Naphtha into valuable MS blending component.

Revamp of the existing units shall be carried out in the plot area of the existing Prime-G and DHDS units. New units of CCR and Isomerisation will be installed in the available bare land at southern side of existing refinery plot area. Hence no additional land is required for the proposed quality improvement project and no new rehabilitation and resettlement plan will be required.

1.4. Justification and Need for the Project

India follows fuel and emission norms in line with the European standards, known as Euro norms. It specifies fuel standards to meet emission norms corresponding to Euro norms. So, Bharat Stage IV corresponds to Euro-IV and BS-VI corresponds to Euro-VI. To meet BS VI emission norms, oil companies will be required to supply petrol and diesel confirming to specifications notified through a Gazette notification. As per Auto Fuel Policy 2025, The Ministry of Petroleum and Natural gas has laid down a roadmap for complete transition to BS VI auto fuels by the 1st April 2020 in the entire country.

As per the Auto Fuel Quality Vision Policy 2025 and communication by MoP&NG on 22nd May 2015, it has been proposed to implement BS-VI grade fuel in the entire country with effect from 1st April 2020.

IOCL, Mathura received the specification of BS-VI from the Centre of High Technology (CHT), which will reduce the sulphur content in MS pool to 10 ppmw. Hence to meet the stringent specifications of BS-VI MS and HSD as per the Government of India guidelines and also to provide the cleaner fuel to the customer it is necessary to undergo Quality Improvement Project for the existing Refinery that involves revamping of existing DHDS, Prime-G and also the addition of new CCR and ISOM units.

Presently, to produce Motor Spirit (MS) the following major streams produced from various process units of Mathura refinery are blended in different proportions.

1. Isomerate from MS Quality Upgradation (PENEX) unit
2. Treated Gasoline from Gasoline Desulphurization (Prime-G) unit
3. Heavy Reformate from Catalytic Reforming unit

Both Isomerate and Heavy Reformate streams of MS are almost free of any sulphur content. However, sulphur content of Gasoline remains around 100 ppmw. The sulphur specification of MS of BS-IV specification is 50 ppmw, hence Mathura Refiney is currently able to produce the MS meeting BS-IV specifications by blending all above specified MS Streams. However, as per the specification of BS-VI received from Centre of High Technology (CHT), total sulphur content in MS pool shall be 10 ppmw. Hence, in order to produce BS-VI compliant MS from Mathura Refinery considerable reduction in the sulphur content of Gasoline stream would be required for which revamping of Prime-G unit is necessary.

Similarly, for making High Speed Diesel (HSD) complying the BS-VI specifications following major streams produced from various units of the refinery are blended in different proportions.

1. Diesel from Hydro Cracker Unit (OHCU)
2. Diesel from Diesel Hydro Desulphurization Unit (DHDS)
3. Diesel from Diesel Hydro Treatment Unit (DHDT).

Both diesel streams produced from OHCU and DHDT contain sulphur of around 10 ppmw. However, sulphur content of diesel stream produced from DHDS remains around 50 ppmw. The current sulphur specification of HSD as per BS-IV norms is 50 ppmw. Hence, Mathura Refinery is currently able to produce the HSD meeting BS-IV specifications by blending all above mentioned diesel Streams. However, as per the specification of BS-VI received, total sulphur content in HSD pool shall be 10 ppmw. Hence, in order to produce BS-VI HSD from Mathura Refinery considerable reduction in the sulphur content of diesel stream of DHDS unit from 50 ppmw to 8 ppmw would be required for which revamping of DHDS unit is necessary.

In order to convert excess Naphtha currently produced from Mathura Refinery into valuable MS blending component, new CCR and ISOM units have been proposed under QIP. These proposed CCR and ISOM units shall produce the MS blending component of sulphur content less than 10 ppmw which is in line with the BS-VI specifications.

1.5. Location of the Project Site

The proposed Quality Improvement Project will be envisaged within the IOCL Mathura complex. All the revamp of existing units proposed under Quality Improvement (QIP) project shall be carried out in the available plot area of existing Prime-G and DHDS units. Furthermore, new units like CCR and ISOM which are proposed under Quality Improvement (QIP) project shall be installed in the available bare land at southern side of existing refinery plot area. No new land is required for the purpose. Hence, separate Site analysis is not required.

The existing project site is located at Bhainsa village, Mathura Tehsil, Mathura District, Uttar Pradesh and is location is projected in the Figure 1.1. The study area is covered by Toposheet No. 54 E11 and 54 E15. The vicinity map of the IOCL Mathura Refinery is presented in the Figure 1.2.

Figure 1-1 Location of the Project Site

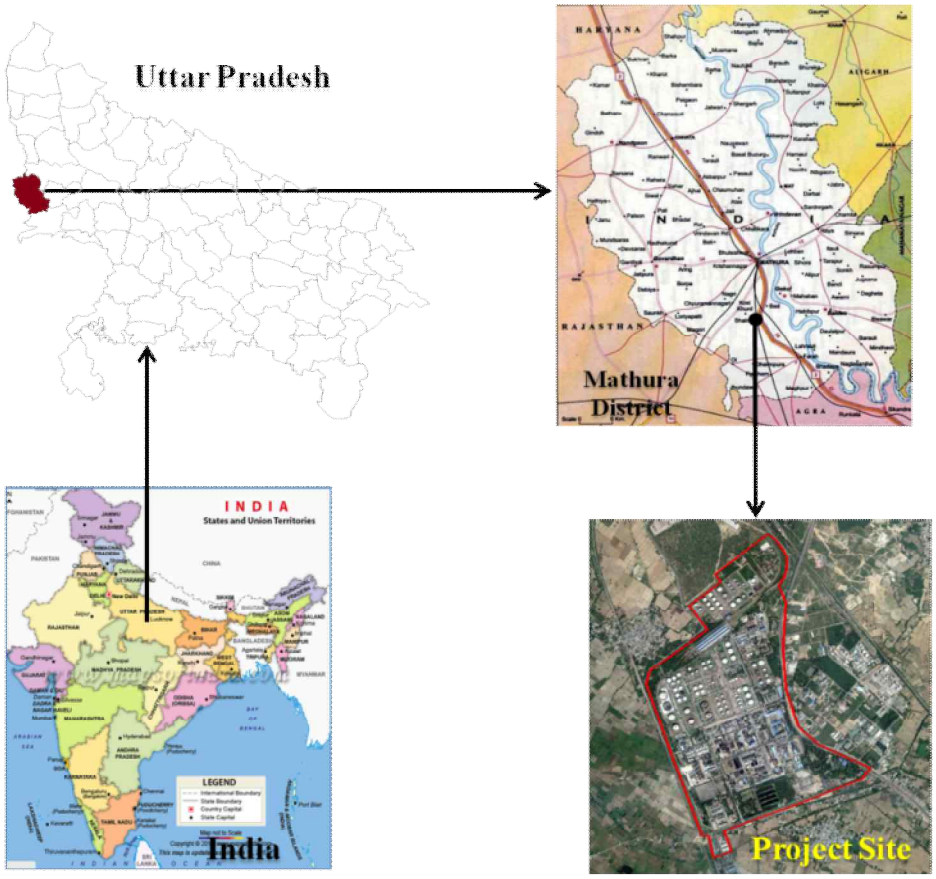
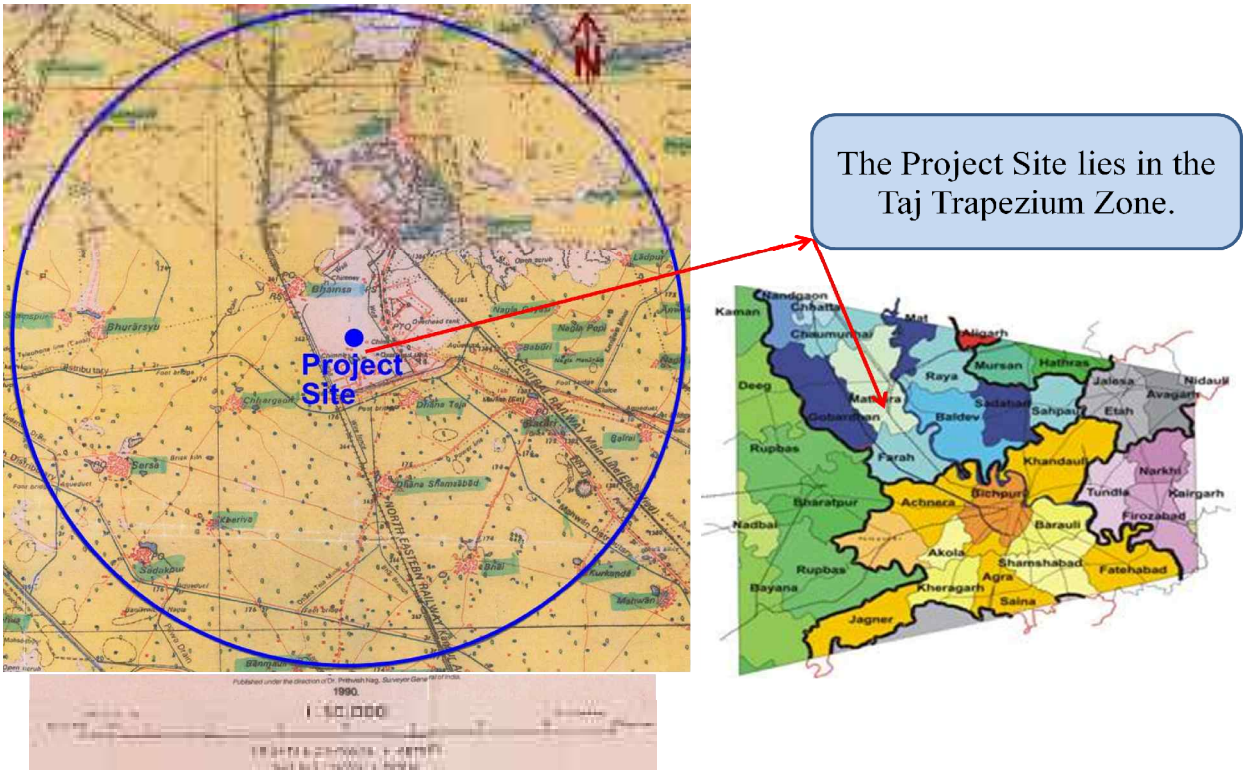


Figure 1-2 Vicinity Map of IOCL Mathura Refinery



1.6. Environmental Setting of the Project Site

The details of environmental setting around the proposed site are given in the following Table 1.1.

Table 1-1 Salient Features of the Project Site Location and its Environmental Sensitivity

S. No.	Particulars	Details
1.	Location	IOCL Mathura Refinery
	Plot/ Survey/Khasra No.	272
	Village	Bhainsa village
	Tehsil	Mathura
	District	Mathura District
	State	Uttar Pradesh
2.	Latitude	27°22'09.15''N to 27°23'32.52''N
3.	Longitude	77° 41'03.69''E to 77°41'53.47''E
4.	Elevation above Mean Sea Level	174 m
5.	Climatic conditions (Annual as per IMD-Mathura)	Annual Mean Max Temp: 44.5°C Annual Mean Min Temp: 2.5°C Annual Mean Rainfall: 633.3 mm Predominant Wind Direction (Blow from): North-West
6.	Site specific climatological data	Maximum Temperature: 37°C Minimum Temperature: 6°C Predominant wind direction(Blow from): North-West
7.	Nearest Highway	• National Highway (NH-2) passing adjoining to the plant Eastern boundary • SH-33, 5 km Northwestern side
8.	Nearest Railway station	• Baad Railway Station at 2 km from project site in Northern direction • Mathura Railway Junction is 10.3 km towards North
9.	Nearest Air Port	Indira Gandhi International Airport at Delhi, 140 km away from plant boundary towards North
10.	Nearest Town	Mathura, 11.8 km, Northern direction from project side
11.	Interstate/National Boundaries	Rajasthan state boundary located at distance of 7.5 km towards western direction from the project site boundary.

S. No.	Particulars	Details
12.	Reserve Forest	Baad R.F, 2 km towards Northern side
13.	Ecologically sensitive zones	No ecologically and archeologically sensitive places are located within 10 km radius of the project site
14.	Archaeological monuments	Project site is located within the geographical limits of Taj Trapezium Zone
15.	Water bodies	Yamuna River flowing at about 6 Km towards Eastern side
17	Defense Installations	Nil within 10 km radius
18	Seismic Zone	Seismic Zone IV as per IS: 1893 (Part-1)-2002
19	Industries near by	Plaza Chemicals Industries-0.5 Km

1.7. Need for EIA Study

According to the Environmental Impact Assessment Notification 2006, issued by Ministry of Environment, Forests and Climate Change (MoEF & CC) under Environment Protection Act all developmental projects of Petroleum refining industry should undertake Environmental Impact Assessment Study (EIA) and obtain necessary Environmental Clearance from relevant authorities.

Since the proposed quality improvement project falls under category "A" under sector 4(a) of the EIA Notification 2006. In this context, IOCL has conducted EIA study to obtain Environmental Clearance for the proposed Quality Improvement Project.

1.8. Project Screening (Cat A) and TOR

The project was appraised by Reconstituted Expert Appraisal Committee (Industry-2), Ministry of Environment and Forest (MoEF&CC) during the 11th Expert Appraisal Committee meeting held on 20-21th July 2016 and the project was accorded Terms of Reference (ToR) vide File no. J-11011/151/2016-IA II (I) dated 23rd September 2016 and the copy of the ToR is enclosed as *Annexure 1.* As per the approved ToR, the Public Hearing for the proposed Quality Improvement Project was exempted as under 7 (ii) of the EIA Notification, 2006.

1.9. Overview of the EIA Study

The EIA study was undertaken in conformity with the guidelines of Ministry of Environment and Forests (MoEF), covering all the aspects of the specific conditions mentioned in the terms of reference issued by MoEF.

This EIA study was undertaken by M/s. Cholamandalam MS Risk Services, a NABET accredited EIA consulting organization by obtaining specific project related inputs required for undertaking the EIA study from IOCL, Mathura.

Cholamandalam MS Risk Services is authorized to undertake EIA studies for Refineries as per the NABET accreditation scheme and the primary baseline data has been generated by Ind Research and Development House Pvt Ltd, Noida, an NABL approved Environmental Testing Laboratory. A copy of NABET accreditation certificate of EIA consultant accreditation is enclosed as *Annexure 2* of this report.

1.10. Overview of the Methodology Adopted

This Environmental Impact Assessment (EIA) report has been prepared based on the methods and guidelines suggested by MoEF&CC to address all the specific conditions stipulated in the Terms of Reference (ToR) issued by EAC with reference file no.J-11011/151/2016-I(A) II(I) dated, 23rd September 2016. A summary of compliance statement to the specific conditions of the terms of reference is presented in Annexure 3. As described in the additional ToR, A copy of the certified compliance report to the environmental conditions prescribed in the existing EC is attached as *Annexure 4.*

The EIA study team, headed by an accredited EIA Coordinator, along with the approved Functional Area Experts, undertook detailed baseline studies and the special studies as per ToR, between *25th November 2016 to 23rd February 2017.*

Micro-meteorological data comprising hourly readings of wind speed, wind direction, dry bulb temperature, relative humidity and rainfall were measured by installing an onsite meteorological station in the plant. Hourly readings were collected for a period of three (3) months.

Micro-meteorological data was adopted for generating wind-rose diagrams and also to predict the ground level concentrations due to release of emissions from the proposed facility.

Ambient Air Quality (AAQ) was measured at eight (8) locations in the study area as per the methods and procedures recommended by Central Pollution Control Board (CPCB). As per the MoEF guidelines, ambient air quality monitoring was undertaken for a period of 12 weeks with a total of 24 samples per site. Stipulated criteria pollutants such as Particulate Matter size less than 10 microns (PM_{10}), Particulate Matter size less than 2.5

microns ($PM_{2.5}$), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Ammonia (NH_3), Ozone (O_3), Carbon Monoxide (CO), Lead (Pb), Nickel (Ni), Arsenic (As), Benzene, Benzo (a) Pyrene (BaP), Hydrocarbons, Total VOCs and Mercury were analysed at all the locations. Air quality modeling exercise was undertaken to establish the ground level concentrations of criteria pollutants of the concern and the possible residual impacts due to release of controlled emissions from the proposed quality improvement project facilities. The measured background air quality data was compared with that of the prevailing National Ambient Air Quality Standards and this will also form the basis for predicting the cumulative air quality scenario due to the operation of the proposed facility.

Noise levels were measured at eight locations in the study area to monitor the noise levels. Noise generating sources and the expected noise levels were estimated. ISO compliant noise propagation model was adopted to predict likely noise levels at the facility boundary and nearby villages. The results were obtained were compared with the measured values of noise levels.

Hydro-geological studies were undertaken during the study period. Data on sub-surface soil profile and also bore-log data in the study area was obtained. In addition, a preliminary study on the regional and local aquifer status were undertaken based on the primary and secondary published long-term data.

Yamuna River is the major water body in the study area located towards Eastern direction from the project site. Two samples of surface water, Ground water samples from eight (8) locations and one sample of treated effluent from ETP were analysed as per the terms of reference for all the designated parameters. The measured values were compared with the respective water standards. Secondary data on the regional ground water status was also collected from the Central Ground Water Board and the State Ground Water Board.

Soil samples were collected at five (5) locations as per the terms of reference and all relevant parameters such as texture, nutrients, heavy metals and other parameters were analysed in the soil samples.

Land use and land cover was mapped using remote satellite imagery, IRS-P6 dated 06-Feb-2016. The data was processed using applicable software models and level 1 land use classification within the study area was developed.

A walkthrough survey was also undertaken in Baad Reserve forest is located in the study area towards Eastern direction at 2 km from the project site. Flora and Fauna survey was undertaken in the study area and all spotted ecological and biological aspects were mapped based on grid sampling method. Bio-diversity density and abundance were estimated. Walkthrough surveys near forest areas and its environs were also undertaken to assess the ecology around the reserved forest. Secondary baseline data in relation to biodiversity was collected from authentic sources.

Primary socio economic survey was undertaken in the study area to capture the socioeconomic conditions, major occupation of the people, drinking water and sanitation facilities, transportation and other amenities in the study area, with a specific reference to the villages located within five (5) km radius of the plant site.

In addition to the above, district level census data published by National Informatics Centre (NIC) was also collected for a detailed analysis on the socioeconomic aspects. Based on the socioeconomic survey, a need based Community Development Plan under Corporate Social Responsibility (CSR) was suggested. Since, land inside the existing plant premises will be used for the quality improvement program hence no land acquisition involved, detailed Rehabilitation and Resettlement studies are not envisaged under this study; however, the indirect impacts on the local and regional community due to the proposed project were studied.

As a part of the environmental impact assessment study, an attempt was made to predict the possible and likely impacts on background environment. Likely air quality impacts due to release of emissions were modeled using ISCST3 model. Ground level concentration of criteria pollutants such as Particulate Matter, Sulphur dioxide, and Oxides of Nitrogen were estimated using ISCST3 model. Hourly meteorological data generated at the plant site was adopted to assess ground level concentrations. Second highest ground level concentrations were predicted and concentration isopleths of the above mentioned pollutants were plotted. The predicted ground level concentrations of the respective pollutants were added to the prevailing baseline concentrations of the

designated pollutants to assess the likely cumulative post project scenario and such values were compared with the National Ambient Air Quality Standards.

A detailed review on the possible environmental discharges such as liquid and solid wastes from the proposed project was undertaken. As per the additional TOR, 50 % of fresh water requirement should meet from treated wastewater and hence opportunities for wastewater recycling were also studied to reduce the fresh water requirement.

A review on the Corporate Social Responsibility Programs proposed - undertaken by IOCL Mathura was conducted based on the information gathered from the facility records and interaction with resource personnel. An attempt was made to establish the positive and negative impacts on the local socioeconomic environment and biodiversity.

Based on the detailed Environmental Impact Assessment Study, various environmental risk mitigation measures were identified. Having undertaken a preliminary technical assessment, a suitable environmental management plan has been developed.

A typical review on the process equipment, pollution control systems, details of wastes and discharges that are envisaged from the proposed project were also undertaken. Such inputs are adopted while predicting various environmental impacts due to operation of the facility and also to suggest an appropriate environmental management plan and environmental monitoring plan.

As per the Terms of Reference issued by MoEF, Quantitative Risk Assessment Study for the Proposed Quality Improvement Project from BS-IV grade to BS-VI grade at Mathura Refinery was undertaken as a part of this EIA study.

1.11. Regulatory Context

The following environmental laws are applicable to the proposed quality improvement project: Environment Protection Act 1986, Water (Prevention and Control of Pollution) Act 1974, Air (Prevention and Control of Pollution) Act 1981, Storage and handling of hazardous material, Hazardous waste (management and handling) rules, 2016.

The following guidelines and regulations are applicable for the proposed project: EIA Notification and its amendments, Emission and wastewater discharge standards stipulated by Ministry of Environment and Forests (MoEF) and Uttar Pradesh Pollution

Control Board (UPPCB), Noise level standards, National Ambient Air Quality Standards, minimum stack height requirements specified by Central Pollution Control Board etc.

1.11.1. Point Source Air Emission Discharge Standards

According to Central Pollution Control Board emission standards for Petroleum oil refineries. The emissions from point sources shall be within the standards as described in Table 1.2.

Table 1-2 Emission Standards for Petroleum Oil Refineries (Using Gas as a Fuel)

Point Source Emission	Pollutants	Limiting Concentration in mg/Nm^3 for Existing Refineries
Furnace, Boiler and Captive Power Plant	Sulphur Dioxide (SO_2)	50 mg/Nm^3
	Oxides of Nitrogen (NOx)	350 mg/Nm^3
	Particulate Matter (PM)	10 mg/Nm^3
	Carbon Monoxide (CO)	150 mg/Nm^3

1.11.2. Fugitive Emission

The limit for fugitive emissions from Petroleum Oil refineries has been in the Environmental Protection Rules. The fugitive emission standards have been defined with respect to specific equipments like pumps, flanges, compressors etc. The major emission from a gas processing facility includes the Volatile Organic Carbon (VOC) and the prescribed limit for VOC emission is given in Table 1.3.

Table 1-3 Fugitive VOC Emission Standards

Component	General Hydrocarbon (ppm)	Benzene (ppm)
Pump/Compressor	5000	2000
Valves/Flanges	3000	1000
Other Components	3000	1000

1.11.3. Emission from Sulphur Recovery Units

Sulphur recovery units having capacity above 20TPD shall have continuous systems for monitoring of SO_2. Manual monitoring for all the emission parameters shall be carried out once in a month. The details of emissions from Sulphur recovery units are tabulated in Table1.4.

Table 1-4 Emission from Sulphur Recovery Units

S.No	Plant Capacity (Tonnes/day)	Parameter	Existing Refineries
1	Above 20	Sulphur Recovery, %	98.7
2	5-20	Sulphur Recovery, %	96
3	1-5	Sulphur Recovery, %	94
4	All Capacity	Oxides of Nitrogen (NOx), mg/Nm^3	350
5	All Capacity	Carbon Monoxide (CO), mg/Nm^3	150

1.11.4. Minimum Stack Height Requirements

According to the environmental protection rules, the minimum stack height of thermal power plants will be defined based on the total sulphur dioxide emission from the stack. It is estimated using the empirical formula $14(Q)^{0.3}$, where Q is the SO_2 emission rate in Kg/hr, subject to a minimum height of 30m.

1.11.5. National Ambient Air Quality Standards

The criteria pollutants that are regulated under the Environmental Protection Act are Particulate Matter size less than 10 microns (PM_{10}), Particulate Matter size less than 2.5 microns ($PM_{2.5}$), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Ammonia (NH_3), Ozone (O_3), Carbon Monoxide (CO), Lead (Pb), Nickel (Ni), Arsenic (As), Benzene and Particulate phase Benzo(a)Pyrene (BaP). Summary of the Ambient Air Quality standards are presented in Table 1.5.

Table 1-5 National Ambient Air Quality Standards

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and Other area	Ecologically sensitive area (notified by central government)
Sulphur dioxide (SO_2) (µg/m^3)	Annual Average*	50	20
	24 hrs**	80	80
Nitrogen dioxide (NO_2) (µg/m^3)	Annual Average*	40	30
	24 hrs **	80	80
Particulate Matter (Size less than 10 µg) (PM_{10}) (µg/m^3)	Annual Average*	60	60
	24 hrs **	100	100
Particulate Matter (Size less than 2.5 µg) ($PM_{2.5}$) (µg/m^3)	Annual Average*	40	40
	24 hrs **	60	60

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and Other area	Ecologically sensitive area (notified by central government)
Ozone (O_3) (µg/m^3)	8 hrs **	100	100
	1 hrs **	180	180
Lead (Pb) (µg/m^3)	Annual Average*	0.5	0.5
	24 hrs **	1.0	1.0
Carbon monoxide (CO) (mg/m^3)	8 hrs **	2	2
	1 hrs **	4	4
Ammonia (NH_3) (µg/m^3)	Annual Average*	100	100
	24 hrs **	400	400
Benzene (C_6H_6) (µg/m^3)	Annual*	5	5
Benzo(a) Pyrene (BaP)- Particulate phase only (ng/m^3)	Annual*	1	1
Arsenic (As) (ng/m^3)	Annual*	6	6
Nickel (Ni) (ng/m^3)	Annual*	20	20

** Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.*

*** 24 hourly/8 hourly/1 hourly monitored values, as applicable, shall be compiled with 98% of the time in a year. However 2% of the time, it may exceed the limits but not on two consecutive days of monitoring.*

1.11.6. Noise Standards

The Ambient Air Quality Standards in respect of Noise has been defined by CPCB and published under Environment Protection Rules 1986, under The Noise Pollution Regulation and Control Rules 2000. The Noise limit as prescribed by the regulation is given in the Table 1.6.

Table 1-6 Ambient Air Quality Standards in Respect of Noise

Area Code	Category Area	Limits in dB (A) Leq	
		Day Time	Day Time
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silence zone	50	40

Day Time: Between 6 AM and 10 PM / Night Time: Between 10 PM and 6 AM

Silence Zone is defined as an area comprising not less than 100 meters around hospitals, educational institution and courts. The silence zones are to be declared by the Competent Authority.

1.11.7. Petroleum Refineries- Specific Treated Wastewater Discharge Standards

The relevant standards for Petroleum refineries for the wastewater discharge as per Environment Protection Agency (EPA) Notifications are presented in the following Table.1.7

Table 1-7 Specific Treated Wastewater Discharge Standards

S.No	Parameters	Limiting Values for Concentration, (mg/l, expect pH
1	pH	6.0- 8.5
2	Oil & Grease	5
3	BOD 3 days, 27C	15
4	COD	125
5	Suspended Solids	20
6	Phenols	0.35
7	Sulphides	0.5
8	CN	0.2
9	Ammonia as N	15
10	TKN	40
11	P	3
12	Cr	0.1
13	Total Cr	2.0
14	Pb	0.1
15	Hg	0.01
16	Zn	5.0
17	Ni	1.0
18	Cu	1.0
19	V	0.2
20	Benzene	0.1
21	Benzene (a) Pyrene	0.2

The treated wastewater discharge standards have been prescribed in the Environmental Pollution Rules, 1986 under Schedule VI. The standards for discharge of treated effluent into inland surface waters, public sewers, land for irrigation and marine coastal areas for criteria pollutants as prescribed by CPCB is given in Table 1.8.

Table 1-8 General Standards for Discharge of Environmental Pollutants (Effluents)

S.No	Parameter	Standards			
		Inland Surface water	Public sewer	Land for irrigation	Marine Coastal areas
1	Suspended Solids (mg/l)	100	600	200	1. For process wastewater – 100 2. For cooling water

S.No	Parameter	Standards			
		Inland Surface water	Public sewer	Land for irrigation	Marine Coastal areas
					effluent – 10 percent above total suspended matter of influent
2	pH	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
3	Temperature	Shall not exceed 5^0C above the receiving water temperature	-	-	Shall not exceed 5^0C above the receiving water temperature
4	Oil and Grease (mg/l)	10	2	10	20
5	Total residual chlorine (mg/l)	1	-	-	1
6	Ammoniacal Nitrogen (mg/l)	50	50	-	50
7	Total Kjeldahl Nitrogen (as NH_3) (mg/l)	100	-	-	100
8	Free Ammonia (as NH_3) (mg/l)	5	-	-	5
9	BOD (mg/l)	30	350	100	100
10	COD (mg/l)	250	-	-	250
11	Arsenic (mg/l)	0.2	0.2	0.2	0.2
12	Lead (mg/l)	0.1	1.0	-	2
13	Fluoride (mg/l)	2	15	-	15
14	Dissolved phosphates (mg/l)	5	-	-	-
15	Sulphide (mg/l)	2	-	-	5
16	Phenolic compounds (mg/l)	1	5	-	5
17	Iron (mg/l)	3	3	-	3
18	Nitrate Nitrogen (mg/l)	10	-	-	20

1.11.8. Hazardous Waste Management

The Ministry of Environment & Forests (MoEF) has enacted the Hazardous Waste (Management, Handling and Trans boundary movement) Rules, 2016 to ensure effective collection, storage, treatment, reception, import and disposal of hazardous wastes. Any occupier or unit generating hazardous wastes and involved in the above said activities will have to obtain authorization from the respective pollution control board. The unit shall also submit yearly compliance statements to the pollution control board indicating the total quantity of hazardous waste generated in the previous

financial year and the method of disposal of the same. The list of processes generating hazardous wastes have been identified and listed in Schedule I of the Hazardous Waste Rules 2016.

1.12. Structure of the EIA report

This EIA report is structured into nine chapters as below.

Chapter **1** – Introduction

Chapter **2** –Environmental Compliance and Environmental Management Aspects in the Existing facilities- Overview of the of the existing facilities and consents issued (EC, CTO etc), Summary of the environmental compliance, Air pollution sources, stacks as per the CTO and summary of the emission test results, Water consumption and water balance in the existing facility, Wastewater quality and ETP data, Summary of various environmental monitoring programs adopted, Details of the environmental management cell

Chapter 3- Proposed Project Description presents details of the proposed project, process and material balance, raw-materials and details of various supporting facilities required for the project, and an outline of the project cost and project implementation schedules.

Chapter **4** – Baseline Environmental Status presents a comprehensive description of the baseline environmental conditions of the study area. This includes the data obtained from primary surveys and also secondary published data from various authentic sources. All the specified environmental components such as meteorological data, air quality, noise levels, surface and ground water resources, surface and ground water quality, geological and mineralogical features, soil quality, land use and land cover in the study area, cropping pattern, ecological and biological environmental conditions and socioeconomic and cultural aspects of the proposed. All the relevant aspects as mentioned in the Terms of Reference (ToR) were thoroughly addressed

Chapter **5** – Anticipated Environmental Impacts and Mitigation Measures presents the environmental aspects associated with the proposed project, envisaged emissions and discharges from the facility, an overview of various pollution control systems proposed under project planning activities in the detailed project report and construction and operational phase environmental impacts.

Chapter **5** –Analysis of Alternatives

Chapter 6- Environmental Monitoring Program presents monitoring plan which include measurement methodologies, frequency, location, data analysis, reporting schedules, emergency procedures, & detailed budget.

Chapter **7** – Additional Studies this chapter describes various additional studies carried out for the project such as risk assessment study, occupational health related aspects etc.

Chapter **8** – Project Benefits presents the benefits of the project.

Chapter 9– Environmental Management Plan presents the administrative aspects of ensuring that mitigation measures are implemented and their effectiveness monitored, after approval of the EIA.

Chapter 10–Summary and Conclusion presents the summary and Conclusion of EIA Study.

Chapter 11–Disclosure of Consultant presents the declaration by the EIA consultant organisation as per the NABET requirements.

2. ENVIRONMENTAL MANAGEMENT ASPECTS IN THE EXISTING FACILITY

2.1. Overview of the of the Existing Facilities

The existing facility of Mathura refinery produces the Motor Spirit (MS) with Isomerate from PENEX Unit, Treated gasoline from prime G Unit, Heavy Reformate from Catalytic Cracking and Reforming Unit. Isomerate and Heavy Reformate streams of MS are free of sulphur content, whereas sulphur content of Gasoline remains around 100 ppmw. The Mathura refinery is currently able to produce the MS meeting Bharat Stage (BS)-IV specifications by blending the above streams.

The existing facility also produces HSD by complying the BS-IV specifications with Hydro Cracker Unit (OHCU), Diesel Hydro Desulphurization Unit (DHDS) for removal of sulphur and Diesel Hydro Treatment Unit (DHDT). Sulphur of 10 ppmw is produced from OHCU and DHDT and 50 ppmw from DHDS. The Refinery is producing the HSD meeting BS-IV specifications by blending the diesel Streams.

Diesel Hydro-treating unit (DHDT) & MS Quality Up-gradation Unit (MSQU) were installed with world class technology from Axens and UOP respectively in 2005 for production of Euro-III grade HSD & MS w.e.f. 1st April 2005 as per Auto Fuel Policy of Govt. of India. Project for FCC Gasoline Desulphurization (FCCGDS) and Selective Hydrogenation Unit (SHU), the Prime-G technology of Axens, France was commissioned in February 2010 and supply of Euro-IV grade MS and HSD started on continuous basis from February 2010.

The major secondary processing units provided were Fluidised Catalytic Cracking Unit (FCCU), Vis-breaker Unit (VBU) and Bitumen Blowing Unit (BBU). Mathura Refinery is having its own captive power plant, which was augmented with the commissioning of three Gas Turbines (GT) and Heat Recovery Steam Generator (HRSG) in phases from 1997 to 2005 using Natural Gas (NG) as fuel to take care of environment.

For upgrading environmental standards, old Sulphur Recovery Units (SRU) was replaced with new Sulphur Recovery Units with 99.9 % recovery in the year 1999. Mathura Refinery had also set up four nos. of continuous Ambient Air Monitoring Stations far beyond the working area before commissioning of the Refinery in 1982 as a mark of its concern towards the environment and archaeological sites. Its close proximity to the magnificent wonder Taj Mahal adds extra responsibility towards maintaining a cleaner environment. The existing units and year of commissioning at IOCL, Mathura is presented in Table 2.1.

Table 2-1 Existing units at IOCL, Mathura

Unit	Capacity MMTPA	Commissioning Year
Distillation unit (AVU)	8.0	1982
Vis-breaker (VBU)	1.0	1982
Fluidized Catalytic Cracker (FCCU)	1.34	1983
Propylene Recovery (PRU)	0.024	1996
Catalytic Reformer (CCRU)	0.466	1998
Diesel Hydro Desulphurisation (DHDS)	1.1	1999
HGU-I	0.034	1999
Hydrocracker OHCU	1.2	2000
HGU-II	0.06	2005
Diesel Hydrotreater (DHDT)	1.8	2005
MS Quality Upgradation (Penex)	0.44	2005
Gasoline Desulphurisation (Prime-G)	0.525	2010
Sulphur Recovery Units (SRU)	4x60 TPD	1999/2011

IOCL, Mathura has obtained Environmental Clearances form the MoEF&CC for the past projects and the same are presented in Table 2.2. The copy of the latest Environmental Clearance is enclosed as *Annexure-5.*

Table 2-2 List of Environmental Clearances granted by MoEF&CC

S.No	MoEF File No &Date	Project Name	Status of Project
1	J-11011/9/89 IA-II(I), dated- 28th June 1990	PRU, Isobutylene and CCRU	Project commissioned
2	J-11011/15/94 IA-II(I), dated- 19th January 1995	Capacity augmentation from 7.5 to 8 MMTPA	Project commissioned
3	J-11015/65/96 IA-II(I), dated-5th December 1996	Installation of DHDS unit	Project commissioned
4	J-11011/6/2000 IA-II(I), dated-30th April 200	Installation of DHDT unit	Project commissioned

S.No	MoEF File No &Date	Project Name	Status of Project
5	J-11011/283/2006 IA-II(I), dated- 22nd March 2007	FCCU Revamp	Project commissioned
6	J-11011/283/2006 IA-II(I), dated- 11th Oct 2013	Amendment to EC for FCCU Revamp	Project commissioned
7	J-11011/208/2013- IA II(I), dated 19-Sept-2014	Installation of Dimerization unit (55 TMTPA)	Under implementation
8	1555/Praya/SEAC/1555/2013/DD/(DS), dated- 15th Dec'15	Installation of GT-IV (20 Mega Watt)	Under implementation

2.2. Overview of the Existing Facilities

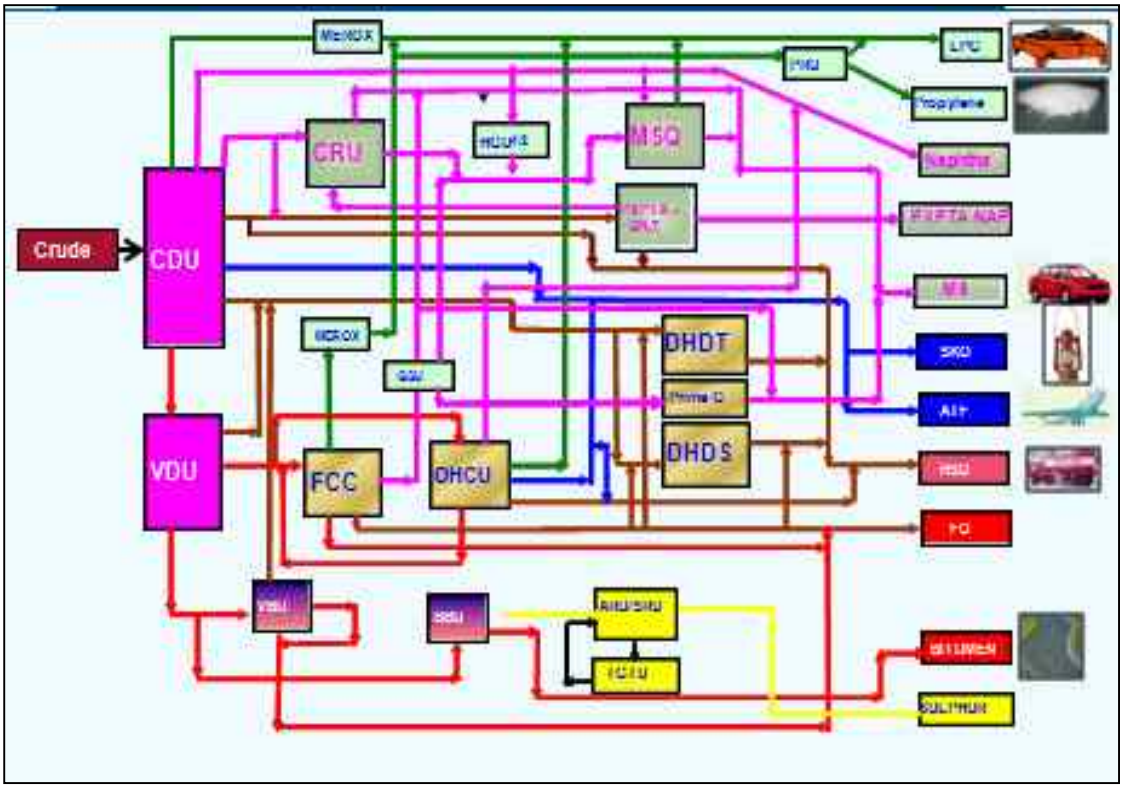
The existing refinery consists of following units,

a) Atmospheric Vacuum Unit (AVU)
b) Fluidized Catalytic Cracking Unit (FCCU)
c) Visbreaking Unit (VBU)
d) Merox Unit
e) Sulphur Recovery unit (SRU)
f) Amine Recovery Unit (ARU)
g) Sour Water Stripper (SWS)
h) Bitumen Blowing Unit (BBU)
i) TPS (Boilers, DM plant and TPS Cooling towers)
j) Tank Wagons Loading
k) Offsite Tankages Area
l) LPG Bulk Storage
m) Flare
n) Continuous Catalytic Reforming Unit (CCRU)
o) Motor Spirit Quality Upgradation Unit (MSQU)
p) Diesel Hydrodesulphurization unit (DHDS)
q) Diesel hydro treatment unit(DHDT)
r) Effluent Treatment Plant (ETP)
s) Once-through hydrocracker unit (OHCU)
t) Prime-G
u) Propylene recovery unit (PRU)

v) Hydrogen Generation unit –I & II (HGU-I & II)

The block flow diagram of existing refinery is provided in Figure-2.1.

Figure 2-1 Block Flow Diagram of Existing Refinery



2.3. Summary of the Environmental Compliance

Mathura refinery is currently operating with a mix of High Sulphur (HS) and low sulfur (LS)crude in the ratio of around 50:50 at crude processing level of 8.0 MMTPA. The industry has obtained CTO vide no. F73255/C-4/Vayu Pradushan -26/16 under Air (Prevention and Control of Pollution) Act, 1981 and CTO vide no. F-73256/C-4/Jal Pradushan-42/2016 under Water (Prevention and Control of Pollution) Act, 1974. The validity of the consent is 31.12.2017. The copy of consent of Air act and Water act are enclosed as *Annexure-5.*

The industry is regularly submitting the Environmental compliance of EC conditions report to Regional Office of MoEF. The copy of the latest compliance report and the certified copy of the compliance are enclosed as *Annexure-4.*

2.4. Overview of Environmental Management Programs adopted by IOCL Mathura Refinery

At Mathura Refinery, technology and ecology go hand in hand with continuous endeavour for Product Quality up-gradation, Energy Conservation and Environment Protection. Mathura Refinery is the first in Asia and third in the world to receive the coveted ISO-14001 certification for Environment Management System in 1996. It is also first in the world to get OHSMS certification for Safety Management in 1998. The list of activities carried out by IOCL, Mathura in concern with environment is presented in Table 2.3.

Table 2-3 List of Activities carried out by IOCL, Mathura in concern for Environment

Year	Activity
1980	Ambient Air Monitoring Stations
1982	ETP, Sulfur Recovery Units
1987	Sludge treatment with hot gas oil circulations
1989	High activity catalyst in SRU
1991	Low coke catalyst in FCCU
1996	Natural gas for Refinery Fuel
1999	New SRUs with Super Claus Reactor
2002	Bio remediation of oily sludge, PVC lined pit
2005	Tail Gas Treatment Scheme
2007	Flare Gas Recovery system, Stepless Control, VBU APH, ETP Modernization
2008	Foggy Cooler in GT; ETP RO for increasing Reuse and Recycle
2009	Solid Waste Management plant in Town ship
2011	SRU-IV commissioned, ISO-14064 certification
2016	Uplinking of stack analysers, effluent analyser to CPCB server.
2016	Signing of MoU by MR with Ministry of water resources , River development and Ganga rejuvenation , Government of India regarding reuse of treated effluent (20 MLD) for Non-potable purposes In Mathura Refinery
Till 2016-17	Over 2.94 lacs trees planted till March'17

2.5. Existing Point Source Air Emissions

During processing of crude oil several waste products are generated. These waste products include flue gases, wastewater and solid wastes. The waste/flue gases include the gases generated in/from the Power plant and various process units mainly from

CDU, CRU, SRU, DHDT, DHDS, OHCU and etc. The atmospheric pollutants from the stacks of these sources include mainly sulphur dioxide, particulates, and nitrogen oxides.

The quantities and the composition of the gaseous, liquid and solid waste that are generated in the plant will be regulated such that their final disposal into the environment meets all the statutory requirements and the environmental impacts are minimised. The summary stack details is given in Table 2.4

Table 2-4 Summary of Stack Details

S.No	Process Units	Stack Characteristic				
		Gas volume – Nm^3/hr	Temperature - ^oC	Gas velocity – m/sec	Tip diameter – m	Stack Height – m
1.	CDU	770043	180	10.6	6.5	60
2.	VDU	42131	180	1.9	3.35	60
3.	VBU-I,II	29802	250	3.5	2.1	60
4.	FCCCH	33855	300	7.6	1.75	60
5.	FCC-Co Boiler	67663	275	7.6	2.5	80
6.	BBU	89650	165	9.4	2.36	40
7.	SRU A	7367	270	7.4	0.8	62
8.	SRU B	7570	270	7.4	0.8	62
9.	SRU C	22789	270	7.4	0.8	62
10.	SRU D	7596	270	7.6	0.8	62
11.	CRU-I	78854	150	10.0	2.15	67
12.	CRU-II	89071	190	10.4	2.23	66
13.	DHDS	12061	185	2.9	1.52	44
14.	OHCU-I	16946	200	3.6	1.47	41
15.	OHCU-II	39394	200	3.5	2.1	41
16.	NHDT	6001	206	4.1	0.9	60
17.	HGU-I	Unit Idle				
18.	HGU-II (PDS)	27850	190	7.8	1.4	60
19.	HGU-II	69724	145	7.5	2.25	60
20.	Prime G	3086	210	3.3	0.8	60
21.	TPS	318535	110	8.5	4.5	116
22.	GT-I	257699	120	9.2	2.5	60
23.	GT-II	260288	120	9.3	2.5	60
24.	GT-III	261452	120	9.4	2.5	60
25.	TGTU	20101	190	9.4	1.12	62

The SO_2 emissions from the stack monitored in the plant through online emission data, external lab & PCB is presented in Table 2.5. The existing latest stack monitoring reports is enclosed as *Annexure-6.*

Table 2-5 SO_2 Emission from the Existing Stacks- External Lab data for the year April 2015 to March 2016

Stack	Existing Operations, Kg/hr
CDU	175.9
VDU	15.8
VBU-I.II	16.6
TGTU	0.1
FCCCH	14.6
COB	67.4
BBU	0.6
SRUs	56.2
CRU-I	2.0
CRU-II	2.1
DHDS	0.4
HGU II PDS	0.0
OHCU-I	0.2
OHCU-II	0.4
NHDT	0.1
NEW HGU-I	--
HGU-II reformer	2.6
Prime G	0.1
TPS & GTs	21.0
Total	376.0

2.5.1. Sulphur Balance in the Existing Facility

All types of crude oils contain sulphur compounds, the amounts of which depend on the crude oil source. During refinery processing these compounds are distributed among the various products, with very little appearing in the lighter products such as gases and gasolines. By adopting the processes for the removal of sulphur from streams used to blend the finished products. This sulphur is normally recovered as elemental sulphur. The existing Sulphur Balance is given in Figure 2.2.

IOCL, Mathura is equipped with three Claus reactors and one Super Claus reactor each of 4x60 TPD. These reactors produces elemental sulphur form the acid gasses and sour gasses streams coming from Amine regeneration and SWS (Sour water Stripping) unit. New standby 60TPD Claus reactor is been installed at the IOCL facility in 2011. 180TPD of tail gas treating unit using Reduction Absorption Recycle (RAR) process is used for recovery of Sulphur form tail gasses streams from SRU.

Figure 2-2 Sulphur Balance for Existing Facility

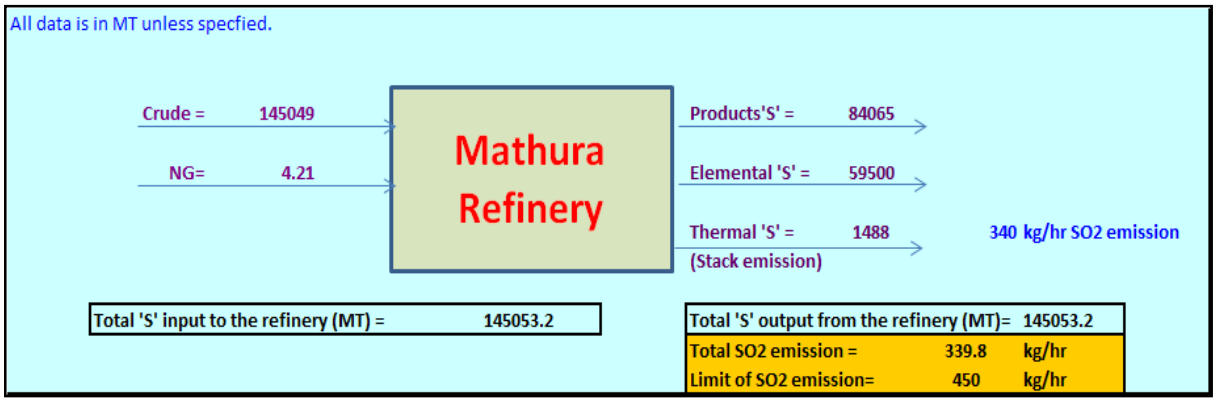


Table 2-6 Summary Table of Sulphur Emissions for Existing

Sulphur Emissions	Existing, MMTPA
Crude Processing Capacity	8
Total sulphur input to the refinery	145049
NG	4.21
"S" in Products	84065
"S" Emissions from other Stacks	1488
Elemental 'S' from SRU	59500
Total Sulphur Output from the refinery	145053

2.5.2. NOx Emissions from the Existing Facility

In order to reduce the NOx emissions from the captive power plant and heaters, low NOx burners are installed. IOCL has installed continuous emission monitoring units on major stacks. It has been estimated that about 156 Kg/hr of NOx is being generated from various stacks within the IOCL refinery for 2016-17.

IOCL has adopted leak detection and repair programs as per the consent conditions. VOC emissions are periodically measured in each of the production department to establish the emissions from pumps, compressors, valves and glands. Plant records confirmed that the overall VOC emissions were found to comply with stipulated fugitive VOC emission discharge standards. Summary of the fugitive VOC emissions are presented in Table 2.7. The reports are attached as *Annexure-7.*

Table 2-7 Fugitive VOC Emissions

(IOCL Plant Quaterly Records : Average data of October to December 2016 & January to March 2017)

S.No	Plant	VOC Emission value in ppm	Total Leak (Kg/day)
1	OM&S(NSU Feed)	28.90	0.17
2	OM&S (Crude)	77.57	0.08
3	OM&S (MS-Manifold)	25.40	0.35

S.No	Plant	VOC Emission value in ppm	Total Leak (Kg/day)
4	OM&S (81 Pump House)	373.62	5.08
5	OM&S (83 Pump House)	115.57	4.27
6	White Oil Gantry-A	27.89	0.83
7	White Oil Gantry-B	85.16	3.30
8	AVU	294.20	10.47
9	CCRU	384.36	11.39
10	PRU	135.06	2.93
11	VBU	59.56	0.71
12	FCCU	267.25	4.80
13	GCU	43.55	0.43
14	MEROX	37.39	0.24
15	DHDS	44.01	1.67
16	DHDT	40.49	1.14
17	HGU-2	172.8	3.16
18	HCU	142.22	4.87
19	ETP	36.91	0.11
20	LPG	112.11	0.64
21	Flare Area	98.19	0.15
22	MSQU	217.04	9.25
23	MSQU-Prime G	45.18	0.96
24	SRU-A	13.08	0.04
		Total	67.04
		MT/Annum	24.47

2.6. Existing Water Consumption and Wastewater Generation

Fresh water required for IOCL Mathura refinery is sourced from Yamuna River and artificial reservoir - Keetham. The total water demand for the existing scenario is presented the entire IOCL refinery complex is presented in Table 2.8.

A Raw Water Treatment Plant (RWTP) is installed near to Keetham Lake. Raw water is subjected to treatment by using coagulation and flocculation process including treatment for disinfection near lake itself. Lake is about 30 kms from Mathura refinery. Chemicals used for this treatment are Poly Aluminium Chloride (PAC), Poly Electrolyte, and Sodium Hypochlorite. Sodium hypochlorite was introduced to phase out chlorine through Electro chlorination process.

Table 2-8 Water Use and Wastewater Generation in the Existing Facility

S.No	Category	Unit	Existing
1	Fresh Water	m^3/hr	669

S.No	Category	Unit	Existing
2	Wastewater discharge into the River	m^3/hr	176
3	Treated wastewater recycling	m^3/hr	402 (70%)

IOCL Mathura refinery complex is permitted to draw about 390 m^3/hr (9360 m^3/day) of water from River Yamuna and 1550 m^3/hr (37200 m^3/day) from Keetham lake. A copy of the consent letter for drawal of water from Irrigation department of Uttar Pradesh Government is presented in *Annexure-8.* The total fresh water consumption in the existing IOCL Mathura Refinery complex was reported to be 669m^3/hr. The overall specific water consumption in the existing facility is reported to be in the order of 0.60 m^3/T of crude processed.

2.7. Existing Waste Water Treatment System

IOCL, Mathura is having a full-fledged effluent treatment plant system for maintaining CPCB discharge standards. The Effluent Treatment Plant is capable of handling 1050m^3/hr to accommodate peak flows in during the wet season. The effluent treatment plant has been modernized in 2008 to meet new environment standard (EP, 2008).

The existing ETP has Oil separation such as API and TPI filter systems and Dissolved Air flotation system (DAF) for further removal of suspended matter and solids. Oil sludge from API, TPI and DAF separator are collected separately in a sump and later centrifuged. The sludge from the centrifuge is further collected in PVC lined pit for bioremediation.

Floated water from the DAF is further sent to Biological section containing of Bio-Tower and Aeration tank for BOD and COD removal. Subsequently wastewater is sent for clarification for removal of suspended solids arrived from biological aeration system.

Final clarified water is subsequently sent to the guard pond and polish pond and further to fire water and green belt and 176 m^3/hr is discharged into the river. 460 m^3/hr of treated water is passed through Dual media Filter (DMF) and Activated Carbon Filter (ACF) for removal of fine suspended solids and colour. The pollutant treatment methods at Effluent Treatment Facility at Mathura Refinery are presented in Table 2.9.

Table 2-9 Pollutant Treatment Methods at Effluent Treatment Facility

S No.	Pollutant	Treatment Method	Equipment
1	Free oil	Gravity separation	API, TPI
2	Emulsified oil	Chemical destabilization and flotation	Dissolved Air Floatation (DAF)
3	Sulphides	Chemical oxidation	Reaction Chamber
4	Organics (BOD/COD)	Biological oxidation & Sedimentation	Bio Tower, Aeration Tank,
5	Settleable Solids	Sedimentation	Final Clarifier
6	Microbes (Bacteria, Algae, etc.)	Disinfection by Chlorination	Chlorine Treatment
7	Suspended solids	Sedimentation & Filtration	Dual Media Filters (DMFs), Activated Carbon Filters (ACFs)

IOCL, Mathura has installed RO system for further removal of TDS and increased recycle of wastewater. Treated water analysis reports are attached as *Annexure-9.* Existing ETP and RO plants and are presented in Figure 2.3 and 2.5 respectively. The photographs of the effluent treatment plant are given in Figure 2.4. Treated water quality is presented in Table 2.10.

Figure 2-3 Existing Effluent Treatment Plant

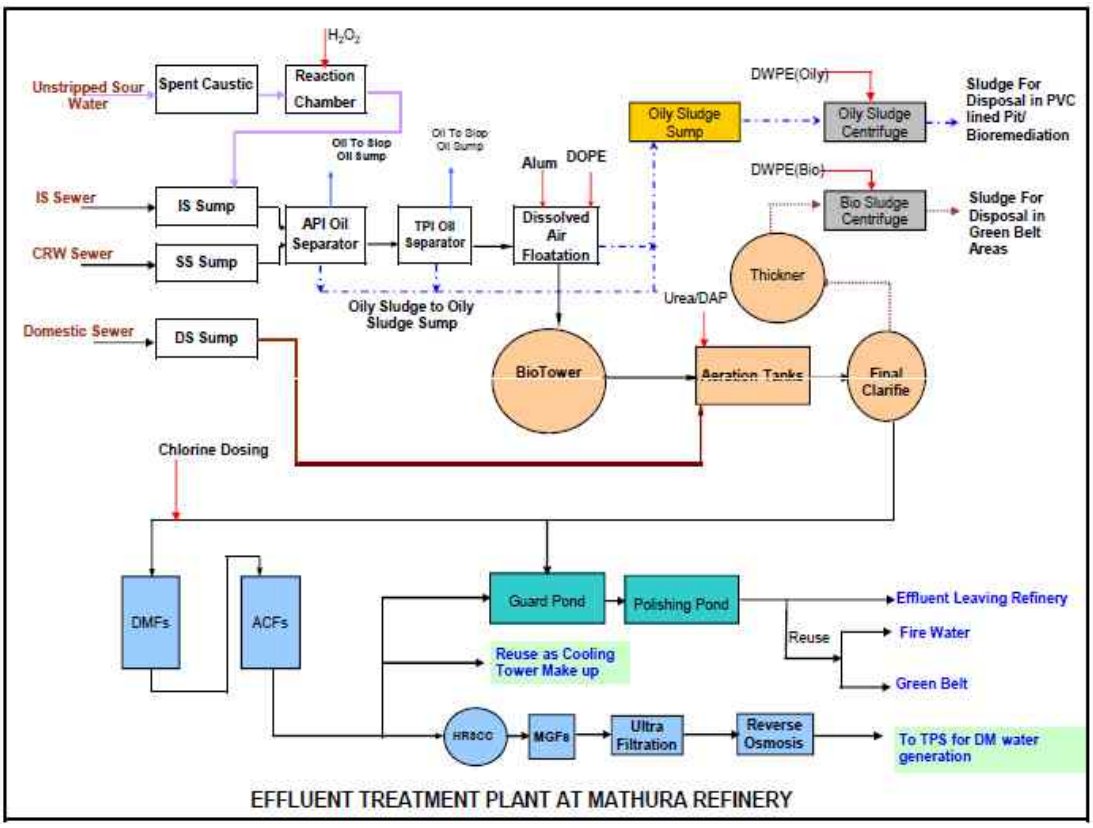


Figure 2-4 Photographs of Effluent Treatment Plant

Aeration Tanks

Dual Media Filters

API Oil Separators

Activated Carbon Filters

2.7.1. Reverse Osmosis (RO) Plant at ETP

In order to increase the reuse and recycle of treated effluent for refinery operations an RO plant based on treated effluent from ETP as feed has been commissioned in Nov 2008. The RO plant takes ACF outlet as feed and produce low TDS RO permeate water as product which is used as feed to DM plant in TPS. The RO plant is designed to produce 150 m^3/hr of RO permeate.

The RO plant consists of 3 main sections

- Pre-Treatment
- Ultra Filtration
- Reverse Osmosis.

The pre-treatment section comprises of High Rate Solid Contact Clarifier (HRSCC), Multi Grade Filters and Basket strainers. The main purpose of the pre-treatment section is to settle the suspended solids present in the feed water. Chemicals namely Lime, Dolomite, Coagulant and Polyelectrolyte are dosed to help the solids settle in the HRSCC. For arresting the carry over solids, if any, from HRSCC the treated water is passed through Multi Grade Filters which are sand filters.

For further removal of solids of very small size the water from the pre-treatment section is passed through the Ultra filtration section. Ultra filtration section consists of membranes, which filters any minute solid particles and reduces the turbidity. The system is backwashed with UF permeate water every 40 minutes for duration of 40 seconds and chemically backwashed every 12 hours for a duration of 12 minutes for removing clogged particles. For preservation of the membranes Antiscalant, Dechlorination Agent (SMBS) and HCL for controlling input pH of the system.

The UF permeate is further processed in Reverse Osmosis section of the plant to generate low TDS water. Before feeding to RO skids the treated water is passed through a micron cartridge filter (5 micron). The water is fed to the RO skids through high pressure pumps. The dissolved solid of the feed water is removed as rejects through the RO membranes, producing low TDS permeate water.

ETP-RO membranes

Ultra Filters at ETP-RO

Figure 2-5 Existing Flow Diagram of Reverse Osmosis Plant

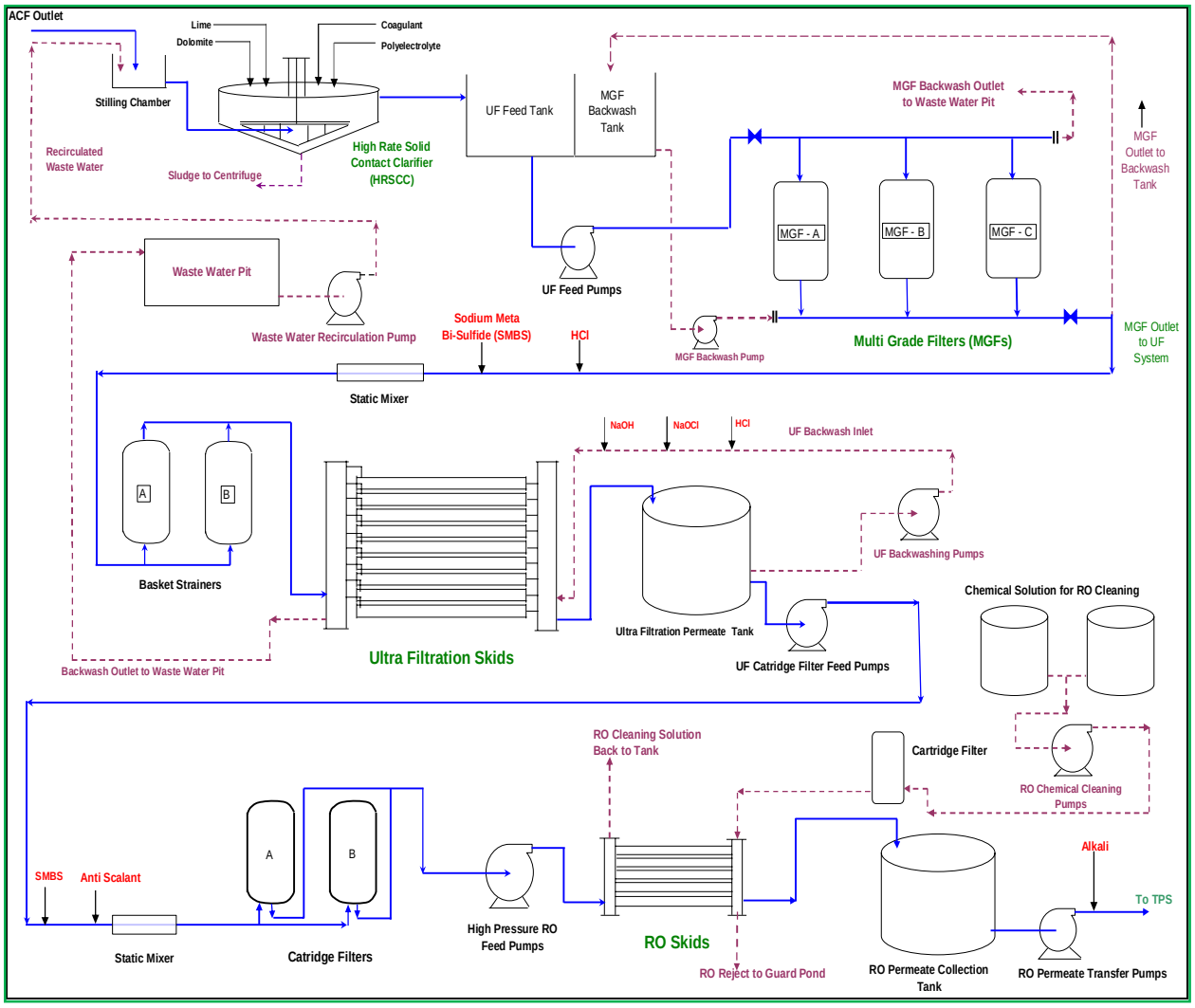


Table 2-10 Treated Wastewater Quality

Parameters	Qty. of Pollution Generated (2016-17)			
	mg/ lit		kg/ 1000 MT Crude Oil	
	Standard	Actual	Standard	Actual
pH	6.0 – 8.5	7.7	-	
Oil & Grease, ppm	5	4	2	1
BOD	15	13	6	2.2
COD	125	123	50	20
Suspended Solids	20	18	8	3
Phenols	0.35	0.1	0.14	0.02
Sulphides	0.5	0.4	0.2	0.1
CN	0.2	ND	0.08	ND
Ammonia as N	15	6.6	6	1.6
TKN	40	13	16	3.2
P	3	0.3	1.2	0.1
Cr (Hexavalent)	0.1	ND	0.04	ND

Parameters	Qty. of Pollution Generated (2016-17)			
	mg/ lit		kg/ 1000 MT Crude Oil	
	Standard	Actual	Standard	Actual
Cr (Total)	2	0.4	0.8	0.1
Pb	0.1	0.03	0.04	0.01
Hg	0.01	ND	0.004	ND
Zn	5	2.5	2	0.6
Ni	1	0.2	0.4	Nd
Cu	1	0.1	0.4	0.04
V	0.2	ND	0.8	ND
Benzene	0.1	ND	0.04	ND
Benzo (a) - Pyrene	0.2	ND	0.08	ND

Note: * Except pH all other parameters units are in mg/lit.

2.8. Solid and Hazardous Waste

Solid waste is mainly generated in the form of Oily sludge in the Effluent Treatment Plant and tank cleaning operations. Details of Solid and Hazardous waste generated in the existing facility are presented in Table 2.11.

Table 2-11 Existing Solid and Hazardous Waste Generation

Oily Sludge from Unit	Existing (MT/year)
ETP	120
Tank Cleaning	200-300
Other Hazardous wastes	Existing (MT/year)
Spent Catalyst	200-250

The refinery is in the practice of disposing residual oily sludge through bio remediation technology which was developed by IOC- R&D. Facility also obtains Hazardous waste consent from UPPCB. IOCL, Mathura is already practicing a safe storage facility for disposal of Hazardous waste in environment friendly disposal methods like bioremediation, metal recovery from spent catalyst, etc.

Bioremediation is a proven method for treatment/disposal of residual oily sludge. In this process, naturally occurring microorganisms transform harmful substances present in residual oily sludge to non-toxic compounds. Large quantities of oily sludge generated at Mathura Refinery has been successfully disposed off through microbial route with encouraging results since initiation of the bioremediation programme in 1999. 'Oilivorous-S Technology' which is jointly developed by IOC (R&D) and The Energy and Resources Institute (TERI) has been used for safe disposal of oily sludge.

Bioremediation of residual oily sludge starts with the application of microbes in batches depending upon the quantity of oil content in the sludge. Recently, bioremediation has been conducted at the new tank farm area site. The oil content in the sludge on zero day is <10 % and the oil content after the completion of bioremediation process is 0.85%. The sludge has been degraded to soil like material after completion of bioremediation as shown in the below Figure2.6.

Figure 2-6 Photographs of Bioremediation

Zero Day | After Completion of Bioremediation

2.9. Existing Green Cover

Massive afforestation activities have been undertaken by Mathura Refinery. Besides serving as a population sink, this green cover also enhances the aesthetic look. Mathura refinery has planted 1, 79,189 tress in the surroundings area including refinery & township. About 1, 15,000 trees have been planted in the Agra region around Taj Mahal.

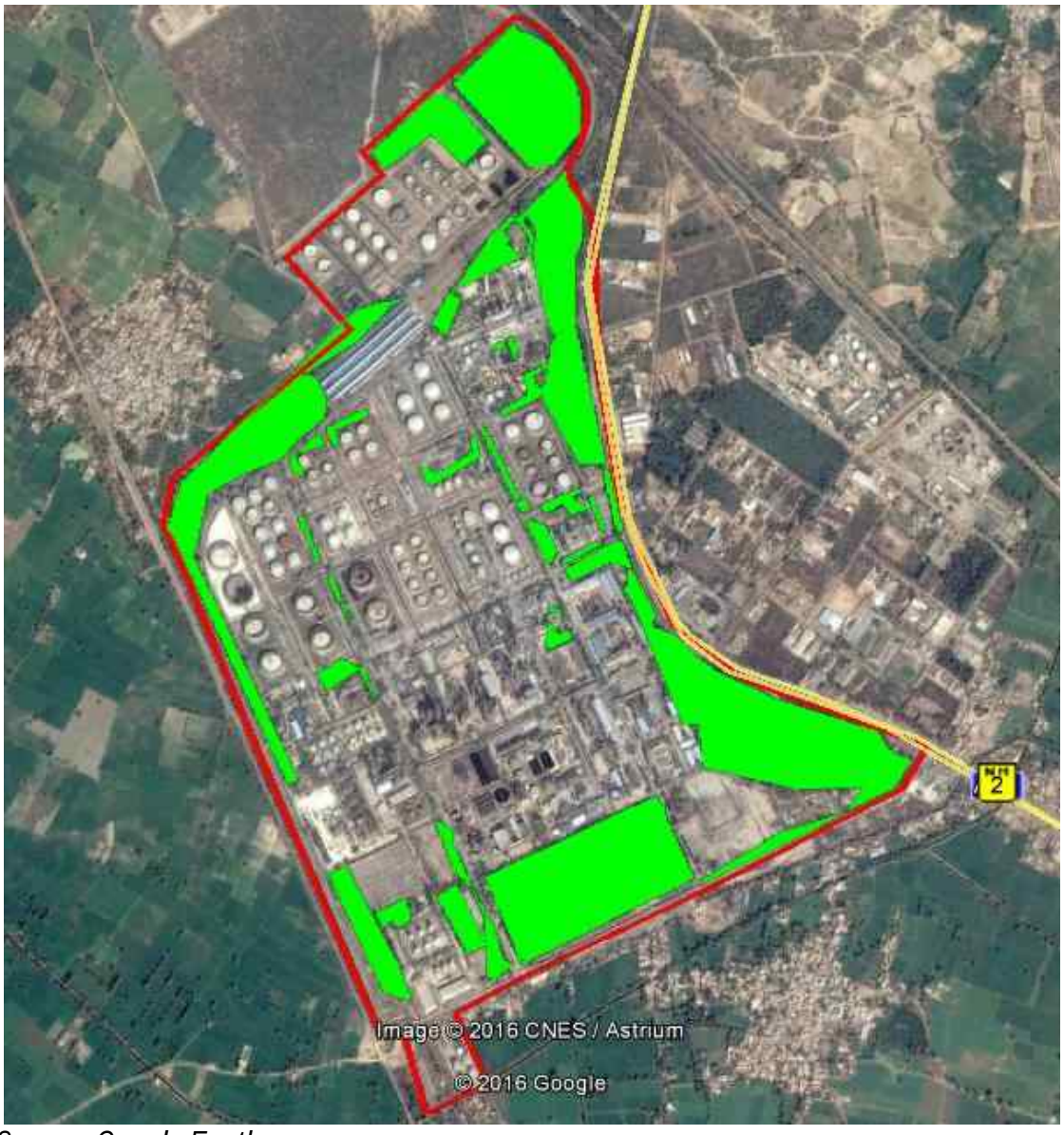
Mathura Refinery, as a responsible corporate entity, is committed for upkeep of the environment beyond its boundaries as well; the refinery has taken extra –ordinary initiatives to provide green cover to the archaeological heritage sites especially the Taj Mahal by planting 80,000 trees in Taj Reserve Forest and 35,000 trees in Renukata Reserve Forest. Plantation has also been conducted in the Mathura region, under this program around 34,459 numbers of selected plant species have been planted in Mathura and Govardhan region.

An ecological park has been developed within the refinery premises. As per the plant records, Tree plantation in the ecological park was done under the guidance of Mr. D.N. Rao, an eminent Professor of the Banaras Hindu University. The google map showing

the greenbelt in the refinery is given in Figure 2.7 and the existing ecological park photographs are presented in Figure 2.8.

A mini bird sanctuary Polishing Ponds of 5nos x 7500 m^3 capacity to provide resistance time for finishing touch with natural aeration. Ninety-six bird species are found in the ecological park out of which 30 migratory birds are recorded as survey conducted by Bombay Natural History Society.

Figure 2-7 Existing Greenbelt area in the IOCL, Mathura



Source: Google Earth

Figure 2-8 Existing Ecological Park at IOCL, Mathura

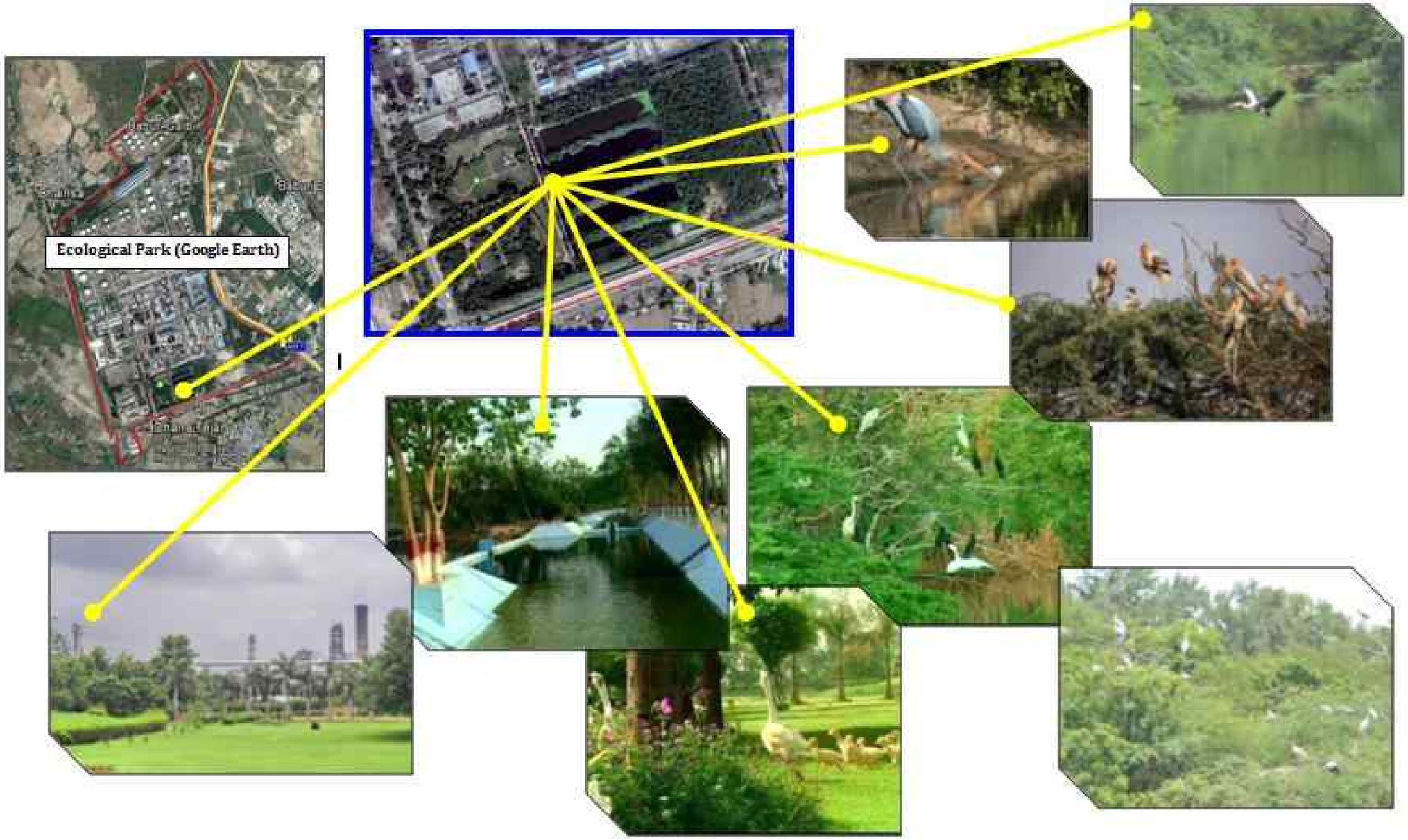


Table 2-12 List of Plant Species under Horticulture and Tree Plantation Activities

S.No.	Botanical Name	Common Name	S. No. As per CPCB Guidelines
1	Acacia Auriculiformis	Australian Wattle, Kikar	A2
2	Acacia Nilotica	Babool	A10
3	Aegle Marmelos	Bel	A22
4	Albizia Lebbeck	Siris	A29
5	Albizia Moluccana	Vilatibaral	A30
6	Alstonia Scholaris	Devil Tree	A36
7	Anthocephalus Kadamba	Kadamba	A40
8	Artocarpus Heterophyllus	Kathal	A42
9	Azadirachta Indica	Neem	A44
10	Bauhinia Acuminata	Kanchan	B6
11	Bauhinia Variegata	Kachnaar	B10
12	Bougainvillea Spectabilis	Bougainvillea	B13
13	Broussonetia Papyrifera	Toot	B15
14	Butea Monosperma	Dhak, Palas, Flame of the Forest	B17
15	Callistemon Lanceolatus	Bottle Brush	C2
16	Calotropis Procera	Aak	C5
17	Carissa Spinarum	Karaunda	C6
18	Cassia Fistula	Amaltas	C7
19	Cassia Siamea	Kassod	C11
20	Casuarina equisetifolia	Whistling Pine, Jangli Saru	C12
21	Citrus Aurantium	Khatta	C15
22	Citrus Limon	Nimbu	C16
23	Cordia Dichotoma	Chota Lasora	C20
24	Dalbergia Sisoo	Sheesham	D2
25	Delonix Regia	Gulmohur, Flame Tree	D3
26	Eucalyptus Globulus	Eucalyptus	E5
27	Ficus Benghalensis	Banyan Treem Bargad	F1
28	Ficus Benjamina	Pakur	F2
29	Ficus Elastica	Rubber Tree	F3
30	Ficus Religiosa	Peepal	F7
31	Grevilla Robusta	Silver Oak	G6
32	Hamelia Patents	Scarlet Bush	H1
33	Hibiscus Rosasinensis	Jasum	H3
34	Ixora Coccinea	Rangan	I3
35	Lantana Camara	Raimuniya	L3
36	Lawsonia Inermis	Mehndi	L4
37	Mangifera Indica	Mango, Aam	M5
38	Melia Azadirach	Bakain	M7

S.No.	Botanical Name	Common Name	S. No. As per CPCB Guidelines
39	Morus Alba	Mulberry	M13
40	Nerium Indicum	Kaner	N1
41	Nyctanthus Arbortristis	Harsinghar	N2
42	Polyakthia Longifolia	Ashok	P9
43	Prosopis Juliflora	Vilayati Kikkar, Vilayati Babool	P15
44	Psidum Guajava	Amrud	P20
45	Tabernaemontana Divaricata	Chandani	T1
46	Tecoma Stans	Sona Patti	T3
47	Terminalia Arjuna	Arjuna	T6
48	Zizyphus Mauritina	Ber	Z1

2.10. Existing Rain water Harvesting System

Rainwater harvesting is a novel method to recharge the ground water level. Mathura Refinery has implemented 14 numbers of Rain Water Harvesting facilities inside the refinery premises and Township. Total catchment area is about 55,000 sq meters and approx 16000 cubic meter water collected from rain is discharged into ground annually.

Figure 2-9 Rain Water Harvesting System

2.11. Existing Storage Tanks and VOC Recovery Systems

Mathura Refinery has a large number of storage tanks catering to the various units viz. Crude distillation unit, secondary process units, HGU Feed, Naphtha, MS, ATF, SKO, HSD, LDO, HPS, Bitumen, slop, etc. The details of storage tanks are attached as *Annexure-10.*

VOC emission monitoring in line with LDAR program as per EP norm-2008 is carried out in general environment and at workplace environment covering various, process units, pump houses, ETP & loading gantries as well. A specialist agency in this field was lined up for monitoring of Fugitive Emission for the entire refinery. Subsequently the repair of leaks is done according to the repair schedule in line with MoEF guidelines. The fugitive emission is well within the stipulated norms in EP amendment rules, 2008.

To minimize VOC emission by constructing floating roof tanks for crude oil & light white oil products and additionally providing secondary seal in combination with primary seal in few floating roof tanks. All the pumps, in light service have been provided with the double mechanical seals.

2.12. Existing Flaring System

The flare system basically consists of Network of pipeline to convey the specified gas stream from various units, flare tip for flaring the specified gas and flame front generator and propagation system for lighting flare pilot burners.

There are two flare stacks of 95m overall height each, one for Hydrocarbon gas comprising and one for hydrocarbon gas comprising of Flare tip, Molecular seal, Water seal drum and Horizontal K.O. Drum and the other for acid gas comprising of Flare tip with the integral gas seal, stack rider only. There is a supporting derrick structure of 95m high surrounding the risers with access platforms at different levels.

2.13. Existing Fire Fighting System

As mandatory requirement, the fire network of refinery has to pressurize at 7 kg/cm^2 minimum as per OISD-116. The treated effluent is reused as make-up to fire-water network entirely, thus saving huge raw water. Existing fire protection facilities will be utilized for the proposed project as per the fire protection facilities manual.

2.14. Occupational Health Centre

IOCL is equipped with full fledged occupational Health Centre within the factory premises. OHC was established on December 1993 to cater the medicals of 1200 employees. OHC is manned by a qualified Medical Officer supported with four paramedical staff.

One Ambulance is stationed in the OHC 24 hours with basic facilities fitted like retractable stretcher, first aid boxes with medicines, oxygen cylinders etc., 74 first aid boxes provided with medicines, kept at vulnerable places inside the refinery. Alike 17 first aid boxes are provided in the company vehicles. The Photographs of the facilities in the Occupational Health centre is given in Figure 2.10

Figure 2-10 Photographs of OHC

Pre-employment medical test is done and the necessary Counselling is done by the Company Medical Officer.

The Company is conducting various health camps like Cardio, diabetic, eye, dental, respiratory etc., for employees and findings are updated in the employee medical history cards at OHC.

Audio metric test, Electrocardiography, Spirometry, Lung function test, Radiography and Physiotheraphy are being conducted periodically for the employees working in strategic places and reviewed.

Health Awareness Programme by a qualified Doctor from outside on various diseases is conducted every month for the benefit of employees.

Photographs of the Various Occupational Health Camps conducted for the employees of IOCL is given in Figure 2.11.

Figure 2-11 Photographs of the Various Occupational Health Camps

Audiometry

Electrocardiography

Physiotherapy

Spirometry

Disaster Room- An Emergency Preparedness

Medical Radiography

Occupational Health Report is enclosed as *Annexure-11.*

2.15. Corporate Social Responsibility of Mathura Refinery

Mathura Refinery undertake the CSR projects short term and long term in consultation with District Administration, request received from Gram Pradhans and based on the recommendations of baseline survey for identified villages around the Refinery. Baseline survey was conducted in 2011 through a NGO, M/s Sankriti Gram, New Delhi

for identifying the activity areas. The survey focused on requirement of infrastructural facilities for schools like buildings, drainage, roads, drinking water facility, provision of teaching aids/ equipments, library, table and chairs etc. The impact study on society due to these executed CSR projects is done by the same agency M/s Sanskriti Gram, New Delhi. The various expenditure incurred by Mathura Refinery on CSR activities is tabulated below in Table 2.13.

Table 2-13 Expenditures incurred by Mathura Refinery on CSR activities

Community Development Programs	Expenditure In Rs Lacs				
	2012-13	2013-14	2014-15	2015-2016	2016-2017
Total	341.51	296.02	448.52	943.16	1116.7

The details of projects /activities carried out are hereunder,

2.15.1. Health Care & Sanitation

For benefit of the locals, Mathura Refinery dedicated a Swarn Jayanti Samudaik Hospital (SJSH)-50 bedded hospital in 5 acres campus located at NH-2. Hospital is manned by 92 Staffs with 12 Doctors, 34 Nurses, 13Para Medical staff, 21 Ward-aid and 12 other Admn. Staff. The hospital has advanced facilities including specialization in burn treatment.

Other than this Hospital another two mobile dispensaries, are operational since 1999, to provide primary medical care at doorstep which is covering 10 villages and recently it is extended to Rawal Panchyat.

Health camp were organized for the community on the eve of Refinery Day, and as a part of CSR program IOCL has Constructed of Toilets for Boys & Girls in various school. Arthroscopy for Surgeons view the joint area was handed over to Ramakrishna Mission Hospital. Medical Mobile Van has also been dedicated to NGO, Ramakrishna Mission



2.15.2. Education

1. Running of Kendriya Vidyalaya at MR Nagar for educating around 1000 students of neighbouring society.

2. Construction of new class rooms for the school in Aduki Village.
3. Providing Furniture / Desk for school children at Rawal & Baad Villages
4. Construction of School Fencing at Rawal Village


5. 30 Girl students sponsored for 03 years GNM Course at RKMS, Vrindavan, Mathura.

2.15.3. Clean Drinking Water

As a part of the community services Mathura Refinery supplies drinking water to the nearby villages. Two number of RO plant for clean drinking water installed in Rama Krishan Mission Sevashram, Vrindaban. One hand pump each at crematorium site in village Dhana Samshabad & Chhargoan and 50 number of Hand pumps were installed in the Adooki, Aganpura, Koyla alipur, Dhana Shamsabad, Dharampura, Dhana Teja, Chadgaon, Baad, Tantura, Raunchi Bangar villages.

2.15.4. Others

1) Rural Development

Road Construction - Refinery provided assistance for repair & maintenance of 800 mtrs of approach road of village Dhana Teja and 1.5 km of road from railway line near refinery to village Chhargaon was undertaken. More than 20,000 people were benefitted by renovation of roads. Refinery also constructed the road for Mohanpur-Addoki to connect NH-2 .

Crematorium Construction: Crematorium was constructed in nearby village of Aganpura and Dhaanateja constructed in 2012-13.

2) Distribution of Solar Lamps

Illuminating the poor families by distributing 100 number of Solar Street light provided for 11 villages which is benefitting approximately 80,000 people.

3) Women Empowerment

As a part of CSR refinery is providing Tailor Training to all Girls & Widows in and around Villages and distributing Sewing Machines to Women from nearby villages.

Skill Development: Empowerment of Unemployed youth through Skill Development Programs in various trades & courses like:

- Form Work Carpentry
- Bar Bending & Steel Fixing
- Masonry – Brick Work & Block Work
- Electrical Technician
- Solar Electrical Technician
- Scaffolding
- Tailoring
- Nursing Course
- Paramedical


निःशुल्क सिलाई प्रशिक्षण कार्यक्रम

3. DETAILS OF PROPOSED EXPANSION

3.1. Overview

This chapter covers details of projects highlighting the features of proposed plant layout and design, details of the proposed process to be adopted, raw material requirement, utilities and services, infrastructural facilities and sources of waste generation, their quantity, treatment and safe disposal of the waste.

As per the Auto Fuel Quality Vision Policy 2025 and communication by MoP&NG on 22nd May'15, it has been directed to implement BS-VI grade fuel in the entire country w.e.f. 1st April 2020. For sustaining the operations of Mathura Refinery, the existing facilities must be upgraded to generate BS-VI grade fuels from 2020 onwards.

The proposed project is for the Quality Improvement Project (QIP) from BS-IV to BS-VI grade at the same crude processing capacity of 8 MMTPA to reduce sulphur content to 10 ppm without increasing the production capacities in the existing refinery. However, there will be only minor modification of few processes in the existing refinery. The existing plant and proposed modifications are presented in Figure 3.1. Details of the existing facilities, proposed revamp units and additional units are presented in Table 3.1.

Table 3-1 Details of Existing Plant, Proposed Revamp and additional Units

S.No	Existing Facilities	Facilities in the QIP for which clearance requested	Remarks
1	DHDS	DHDS	Revamp
2	Prime-G	Prime-G	Revamp
3	--	CCR unit	Additional facility
4	--	Isomerization unit	Additional Facility

Figure 3-1 Existing Refinery with proposed QIP Modifications

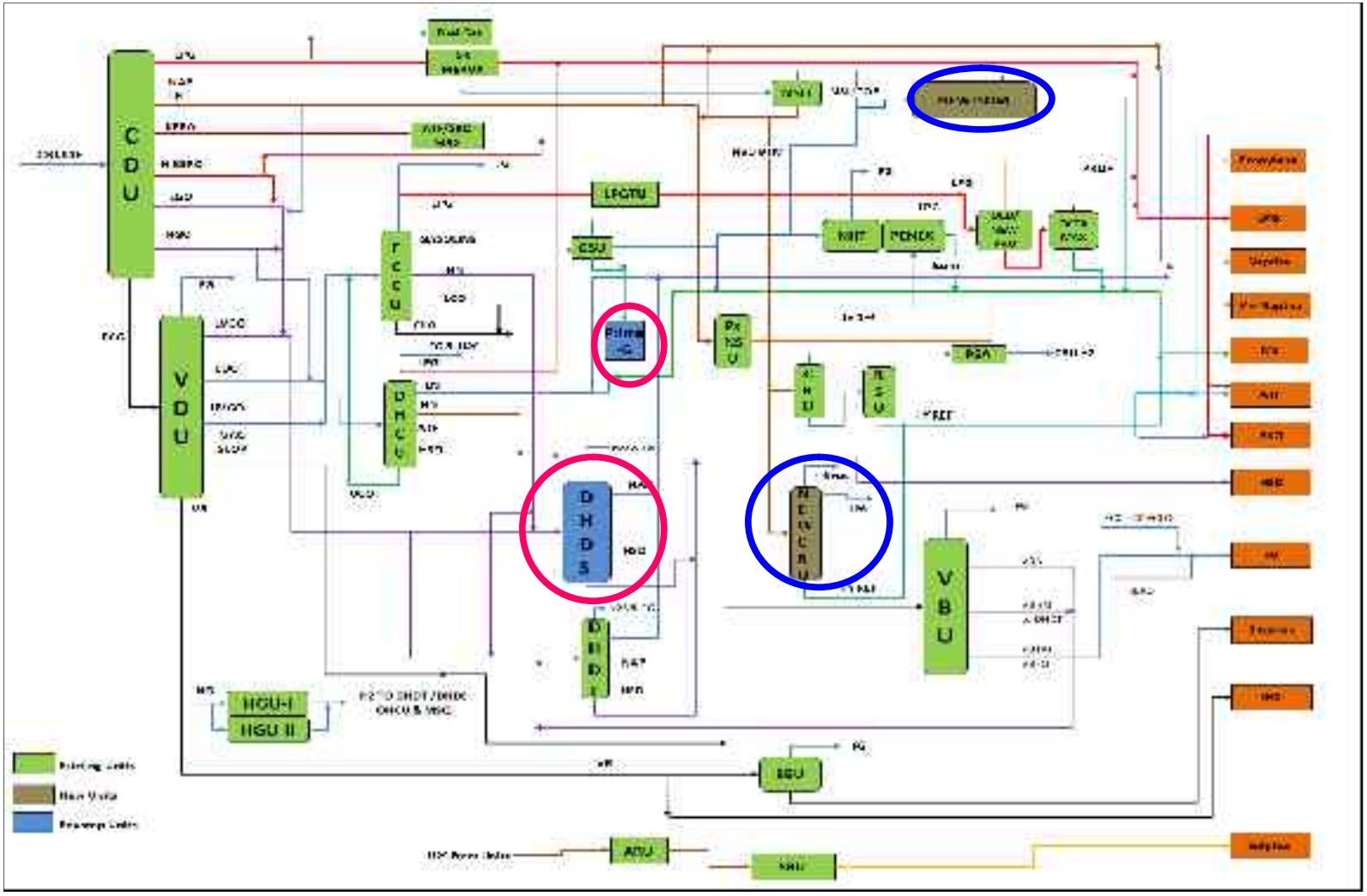


Table 3-2 Overall Pattern of Refinery Pre and Post Revamp under BS-IV and BS-VI Project

S.No	Products	Existing BS IV	QIP	Post QIP
1	Gasoline	1153	145	1298
2	Diesel	2858	0	2858
3	Others	4411	-131	4280
Total		8422	14	8436

3.2. Land for Proposed Expansion

The proposed QIP project will be implemented within the existing IOCL Mathura refinery complex. Layout of the existing IOCL Mathura refinery facilities and location of the proposed project are shown in Figure 3.2. Since the proposed QIP facilities will be undertaken within the existing refinery complex, no additional land will be acquired.

3.3. Site Analysis

3.3.1. Site location aspects

All the revamp activities under Quality Improvement (QIP) project will be carried out in the available plot area of existing Prime-G and DHDS units. Furthermore, new units like CCR and ISOM which are proposed under Quality Improvement (QIP) project will be installed in the available bare land at southern side of existing refinery plot area. No new land will be required for the purpose. Hence, separate Site analysis is not required.

The surroundings of the project site are mostly agriculture land and village settlements. The nearest village, Baburi Sharqi is about 0.75 km from the plant. NH 2 is and the railway network is adjacent to the plant. Yamuna River is about 6 km east from the plant. Google earth image along with site co-ordinates is presented in Table 3.2. Location of the IOCL in Mathura district map is presented in Figure 3.3, Topomap published by Government of India with project site location is presented in Figure 3.4 and Google earth image showing 10km radius is presented in Figure 3.5

Table 3-3 Satellite map showing co-ordinates of the IOCL, Mathura Refinery

Point	Latitude	Longitude
A	27°23'41.21"N	77°41'19.91"E
B	27°23'18.98"N	77°40'53.99"E
C	27°22'54.45"N	77°40'40.15"E
D	27°22'0.36"N	77°41'2.09"E
E	27°22'1.70"N	77°41'9.00"E
F	27°22'27.43"N	77°41'53.77"E
G	27°23'24.16"N	77°41'24.33"E

Source: Google earth as on 6/1/2017

Figure 3-2 Existing layout map of IOCL, Mathura Refinery and proposed Facilities

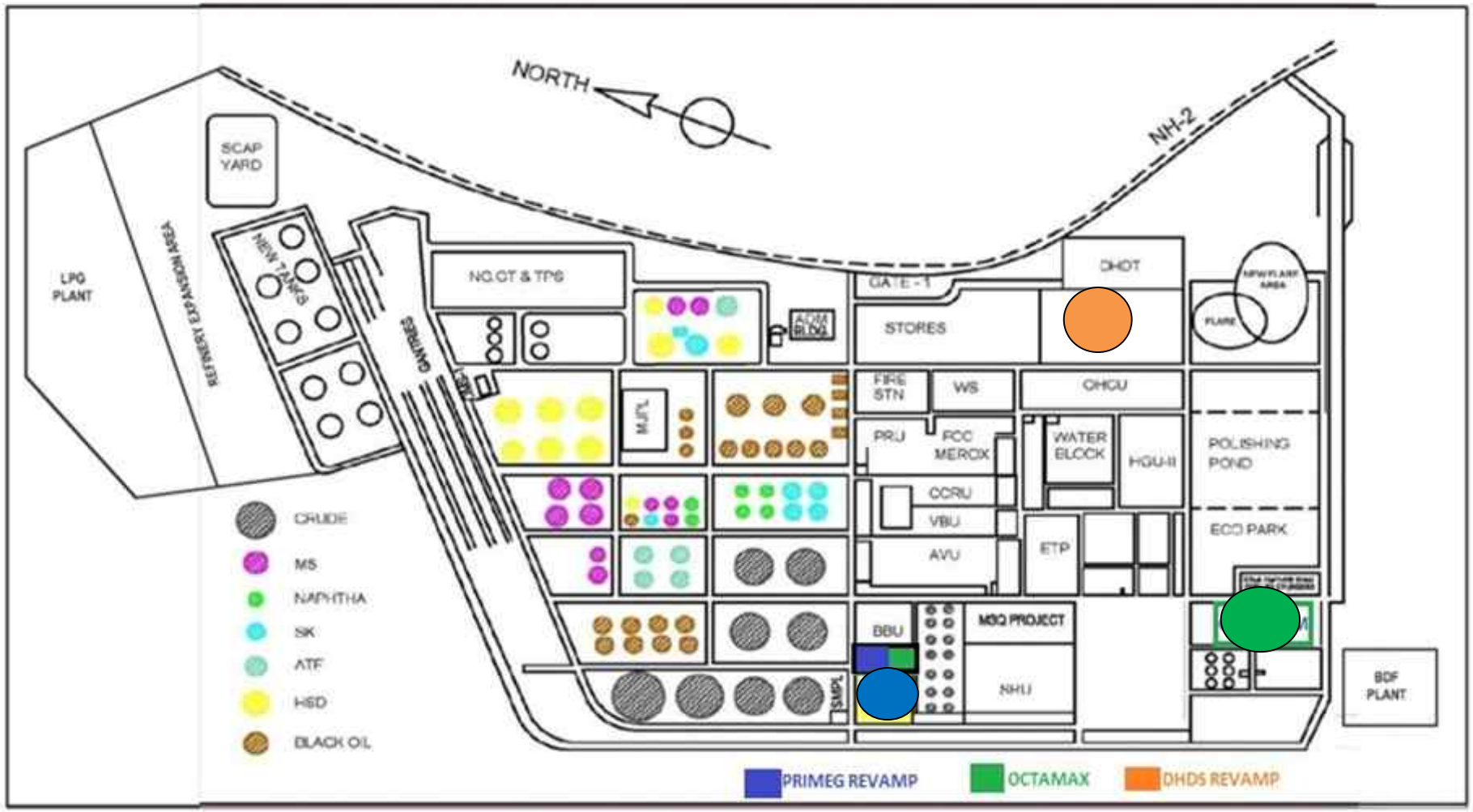
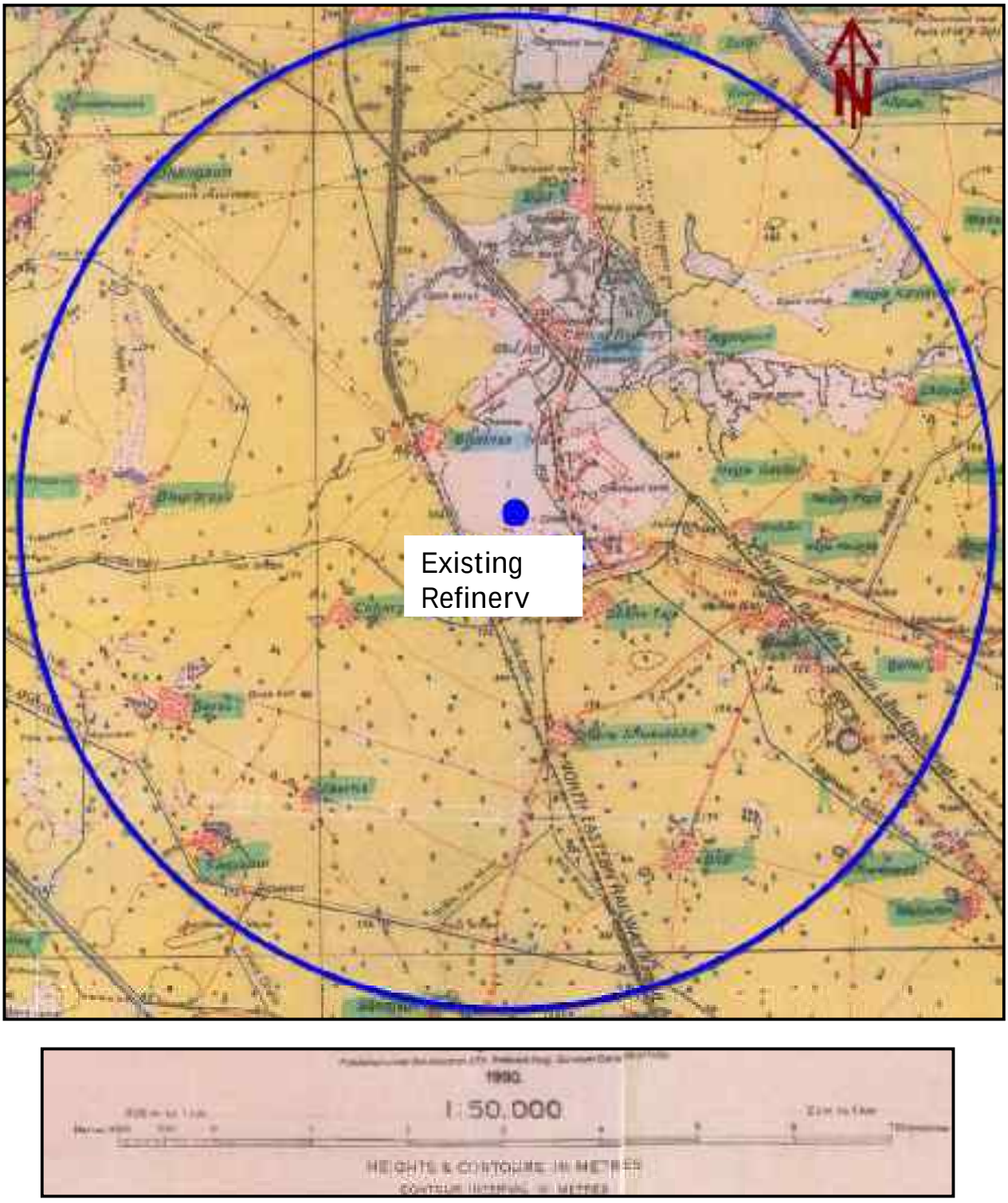


Figure3-3 Location of IOCL Refinery in the Mathura District

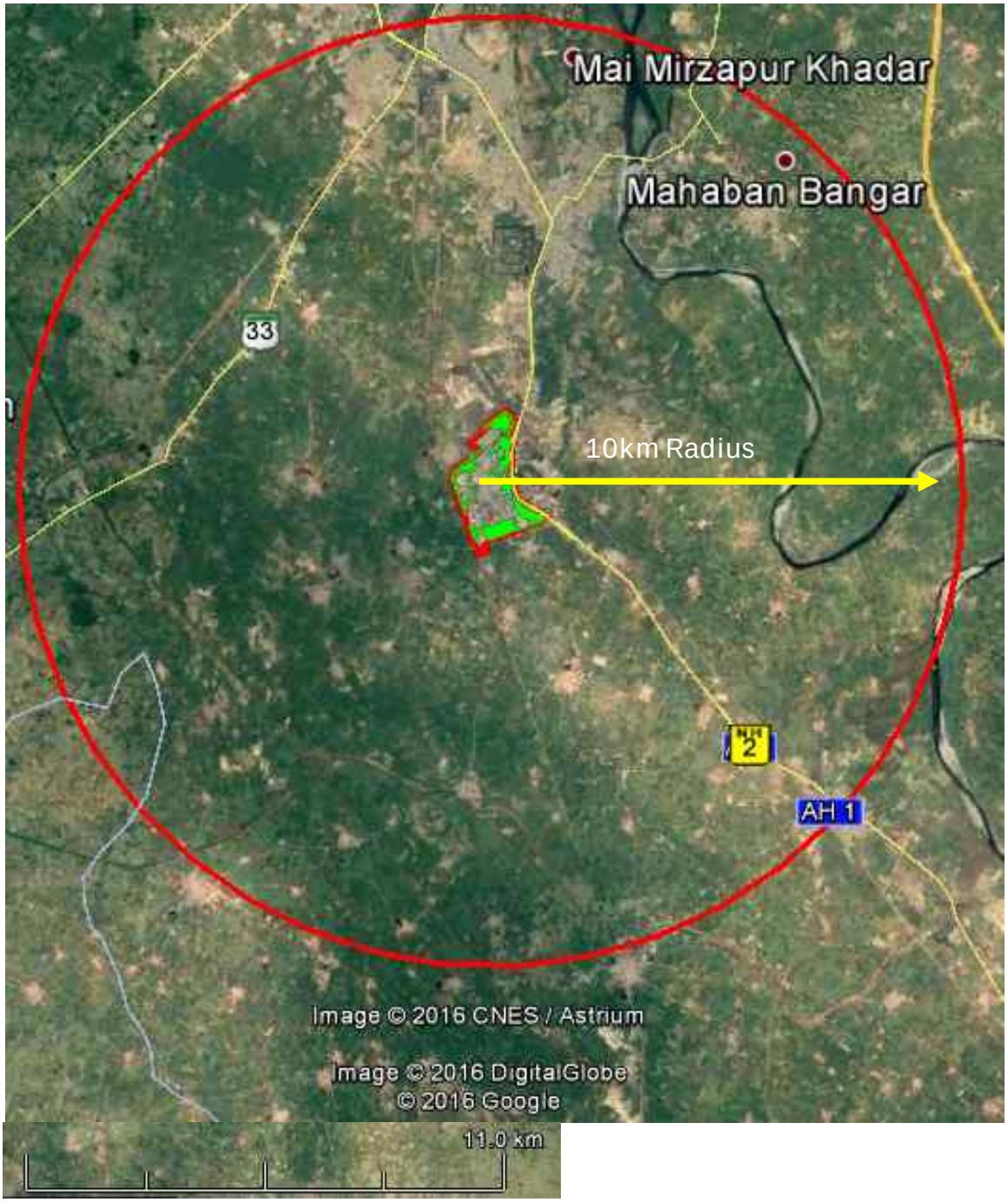
Source: National Atlas & Thematic Mapping Organization

Figure 3-4 Topomap of the IOCL Mathura Refinery



Source: Survey of India

Figure 3-5 10km Radius Google Earth Image



Scale

Source: Google Earth

3.4. Proposed Project

Quality Improvement Project (QIP) is the revamp of the existing DHDS, Prime-G. Apart from the revamp, new CCR and ISOM units are proposed to improve the quality of products produced from these units which shall in result enable Refinery to meet stringent specifications of BS-VI MS & HSD as per the Government of India guidelines.

3.4.1. Prime-G Revamp

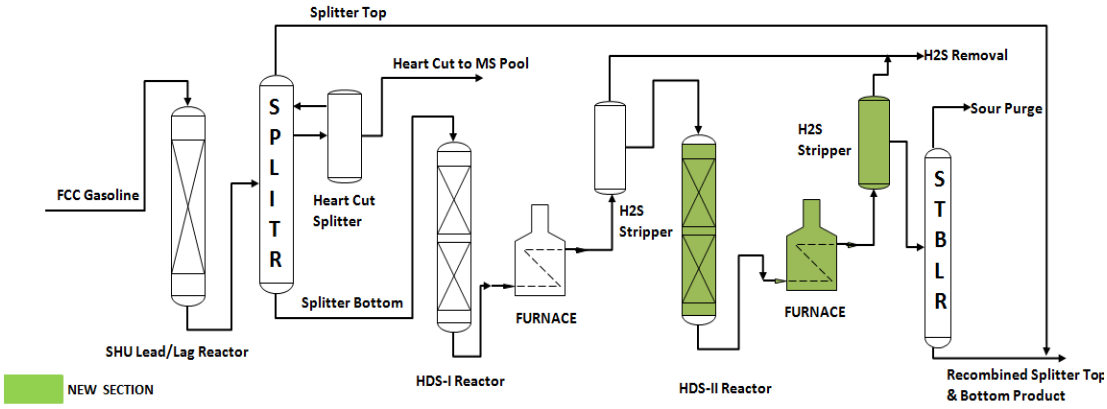
Existing Prime-G unit is of capacity 525 TMTA which was commissioned in year 2009 for reduction in sulphur content of feed Gasoline from 500 ppm to 100 ppm. Currently, as part of Quality Improvement Project, revamp of Prime-G unit is proposed for further reduction in gasoline sulphur content to 8 ppm.

Feed Gasoline to Prime-G unit comes from the existing Fluidized Catalytic Cracking Unit (FCC). Existing plant capacity of Prime-G unit is 525 TMTPA and no change in capacity has been considered in the proposed revamp of Prime-G under QIP.

Post revamp, Gasoline produced from Prime-G shall contain Sulphur of 8 ppm against the current sulphur content of 100ppm. All other properties of product gasoline post implementation of the proposed modification shall be unchanged.

Additional area requirement for the modification proposed around 40x30m^2. The existing redundant area in Prime-G unit will be utilized for installation of the new facilities proposed under this revamp. The block flow diagram of Prime G process is given in **Figure 3.6**

Figure 3-6 Prime **G** Revamp showing New Sections



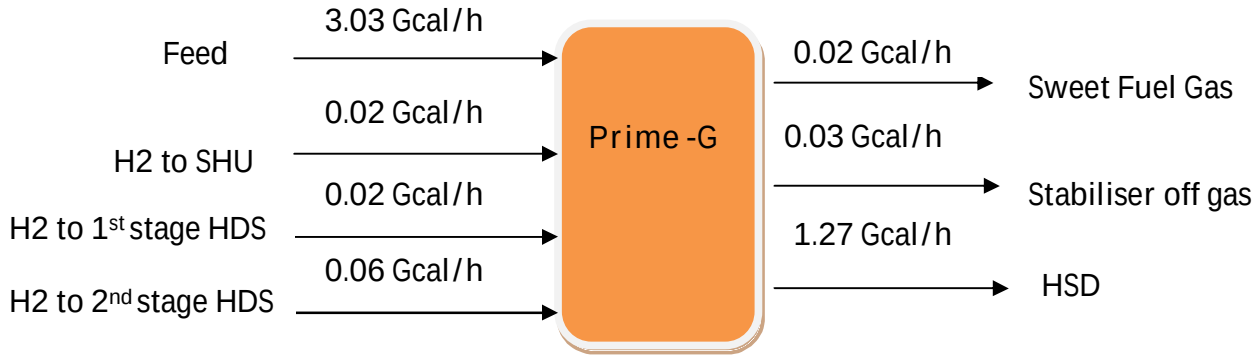
3.4.1.1. Material Balance and Energy Balance for Prime **G** Revamp

Material Balance for Prime G Revamp Unit is given in following Table: 3.4 and the energy balance is given in Figure 3.7.

Table 3-4 **Material Balance for Prime G Revamp**

Description	Quantity in TPH	%wt
Input		
Feed	65.6	99.5
H_2	0.3	0.5
Total	65.9	100
Output		
Fuel gas	0.1	0.19
Gasoline product	65.5	99.29
H_2S+NH_3	0.3	0.52
Total	65.9	100

Figure 3-7 Energy balance for Prime **G** Revamp



3.4.2. DHDS Revamp

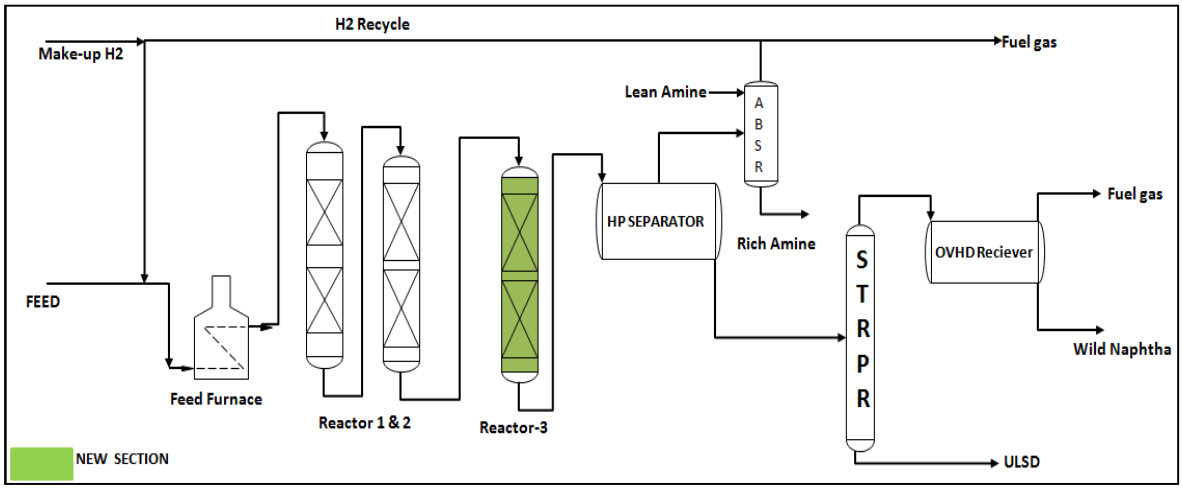
Existing DHDS unit of capacity 1100 TMTPA was commissioned in year 1998 to produce the Diesel stream of 50 ppm sulphur content from the Straight Run Gas Oil (SRGO) of sulphur content of 1.45 wt %. Currently, as part of Quality Improvement Project (QIP), revamp of DHDS unit is proposed for further reduction in Diesel sulphur content to 8 ppm without any reduction in original capacity of 1100 TMTPA.

Feed to DHDS unit comes from the existing Atmospheric and Vacuum units (AVU). Existing plant capacity of DHDS unit is 1100 TMTPA and no change in capacity has been considered in the proposed revamp of DHDS unit under QIP Project.

Post revamp, Diesel produced from DHDS unit shall contain sulphur of 8 ppm against the current sulphur content of 50 ppm. All other Major properties of Diesel produced from this unit shall be unchanged.

Additional area requirement for the modification proposed under is around 30x20m^2. The existing redundant area in DHDS unit will be utilized for installation of the new facilities proposed under this revamp.

Figure 3-8 DHDS Revamp showing New Sections



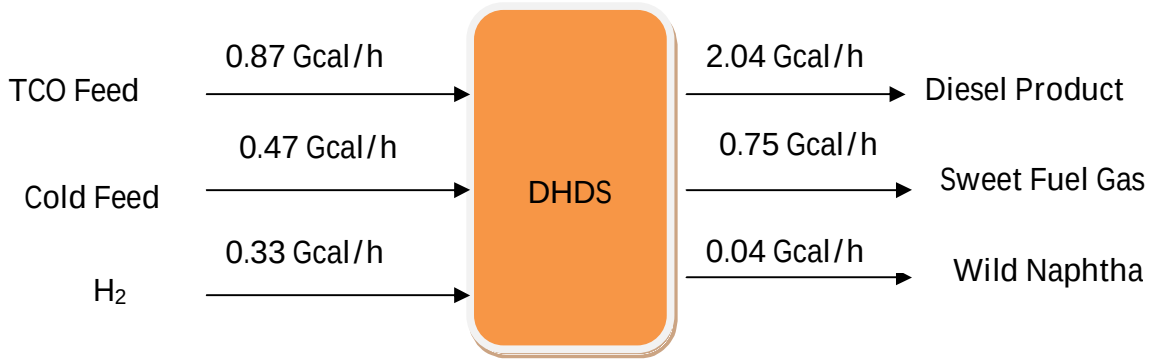
3.4.2.1. Material Balance and Energy Balance for DHDS

Material Balance for DHDS Unit is given in following Table: 3.5 and the energy balance is given in Figure 3.9.

Table 3-5 Material Balance for DHDS

Description	Quantity in TPH	%wt
Input		
Feed	137.5	99.4
H_2	0.8	0.6
Total	138.3	100
Output		
Fuel gas	1.0	0.75
Wild naphtha	1.8	1.29
Diesel	133.6	96.58
H_2S+NH_3	1.9	1.38
Total	138.3	100

Figure 3-9 Energy Balance for DHDS



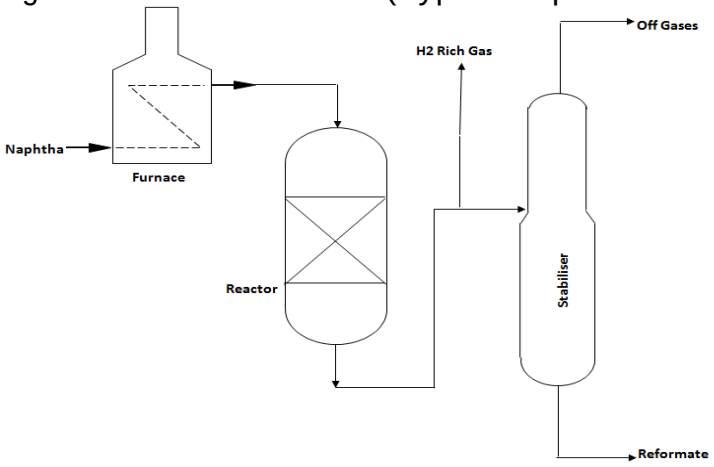
3.4.3. New Continuous Catalytic Reforming (CCR) Unit

New CCR unit along with new Naphtha Hydro Treater (NHT) Unit of capacity 400 TMTPA is proposed as part of Quality Improvement Project. New CCR unit shall convert the excess Naphtha available in Refinery into low sulphur MS stream for production MS of BS-VI specifications.

The feedstock for the proposed new CCR unit is Naphtha of 100-150°C TBP cut which is produced from existing Crude Distillation Unit (CDU). Capacity of proposed CCR unit shall be 400 TMTPA.

Reformate produced from new CCR unit shall be rich in Aromatics and shall content sulphur of less than 10ppm. Hence it is a very good blending component for production of BS-VI grade MS.

Figure 3-10 New CCR Unit (Typical Representation)



Additional area requirement for the installation of the proposed new plant under is around 8000m^2. The existing redundant area available in the southern side of existing

refinery plot area will be utilized for installation of the facilities proposed in new CCR units.

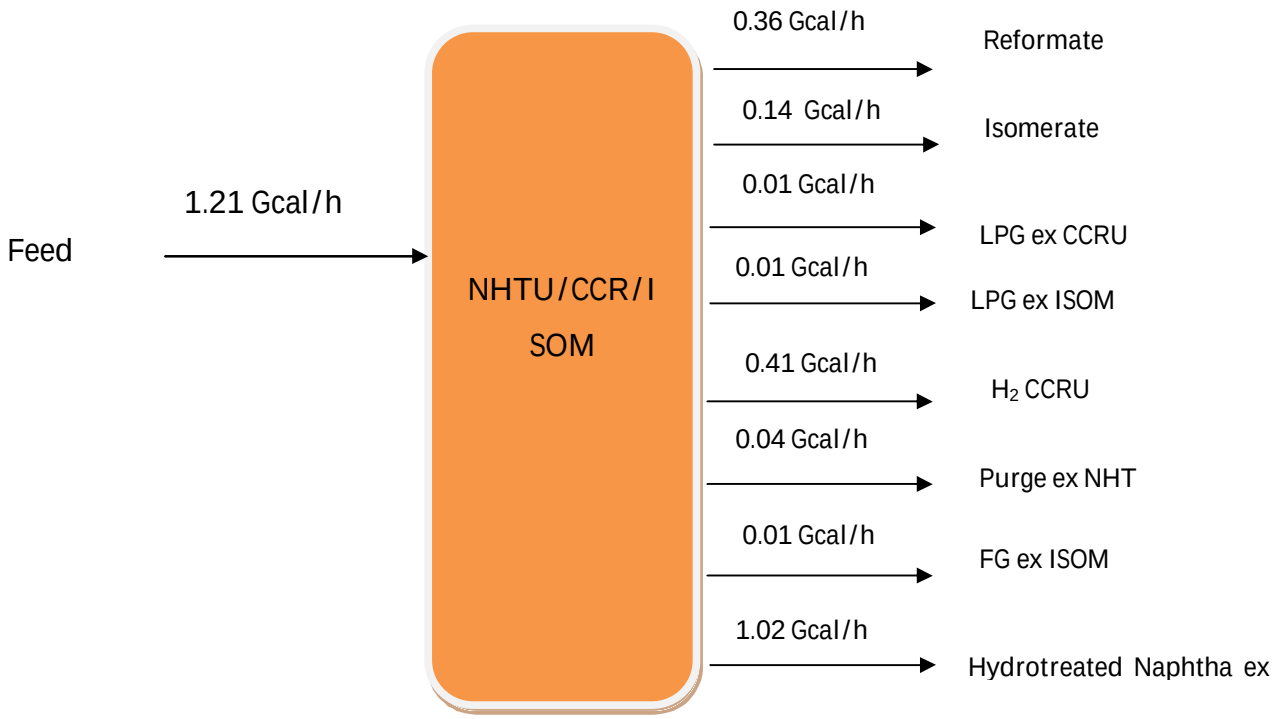
3.4.3.1. Material Balance and Energy Balance for CCR Units

Material Balance for CCR Unit is given in following Table: 3.6 and the energy balance is given in Figure 3.11.

Table 3-6 Material Balance for NHTU, CCRU and ISOM

Description	Quantity in TPH	%wt
Input		
Feed	75	100
Output		
Isomerate	18.5	24.63
Reformate	35.2	46.96
H2 ex PSA	1.2	1.64
LPG	0.7	0.95
Off gases	0.9	1.25
Naphtha	18.4	24.58
TOTAL	75	100

Figure 3-11 Energy Balance for CCRU/ISOM/NHTU

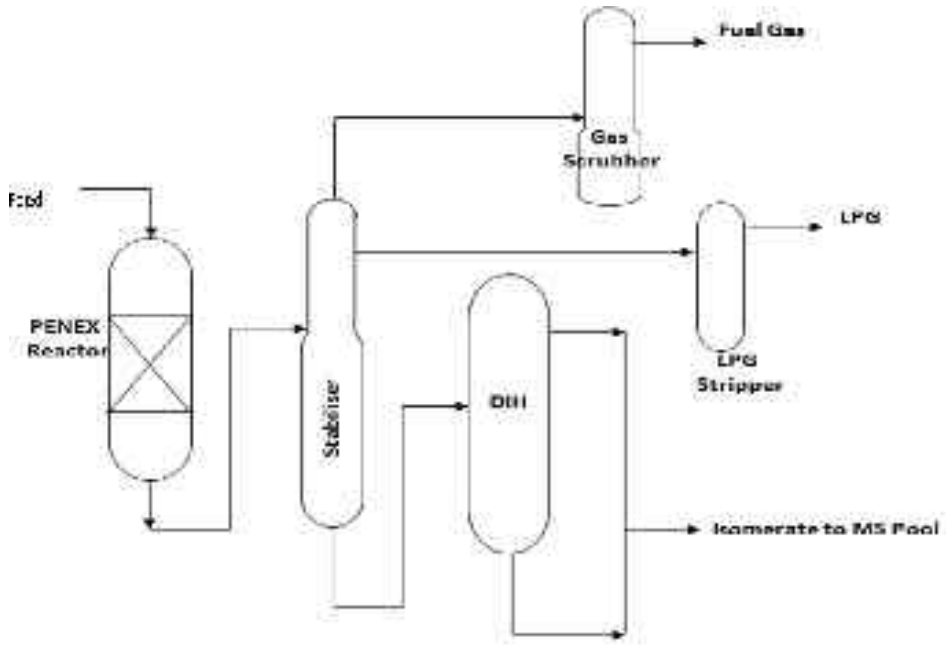


3.4.4. New Isomerisation (ISOM) Unit

New ISOM unit along with Naphtha Hydro Treater (NHT) of capacity 200 TMTPA is proposed as part of Quality Improvement Project. New ISOM unit shall convert the excess Naphtha available in Refinery into low sulphur MS stream for production MS of BS-VI specifications.

The feedstock for the proposed new ISOM unit is Naphtha of C_5- 100 ^{0}C TBP cut which is produced from existing Crude Distillation Unit (CDU). Capacity of proposed ISOM unit shall be 200 TMTPA.

Figure 3-12 Typical Representation of New Isomerisation Unit



Isomerate produced from new ISOM unit shall be low in Aromatics and shall content sulphur of less than 10 ppm. Hence it is a very good blending component for production of BS-VI grade MS.

Additional area requirement for the modification proposed is around 6000 m^2. The existing redundant area available in the southern side of existing refinery plot area will be utilized for installation of the facilities proposed in new ISOM units.

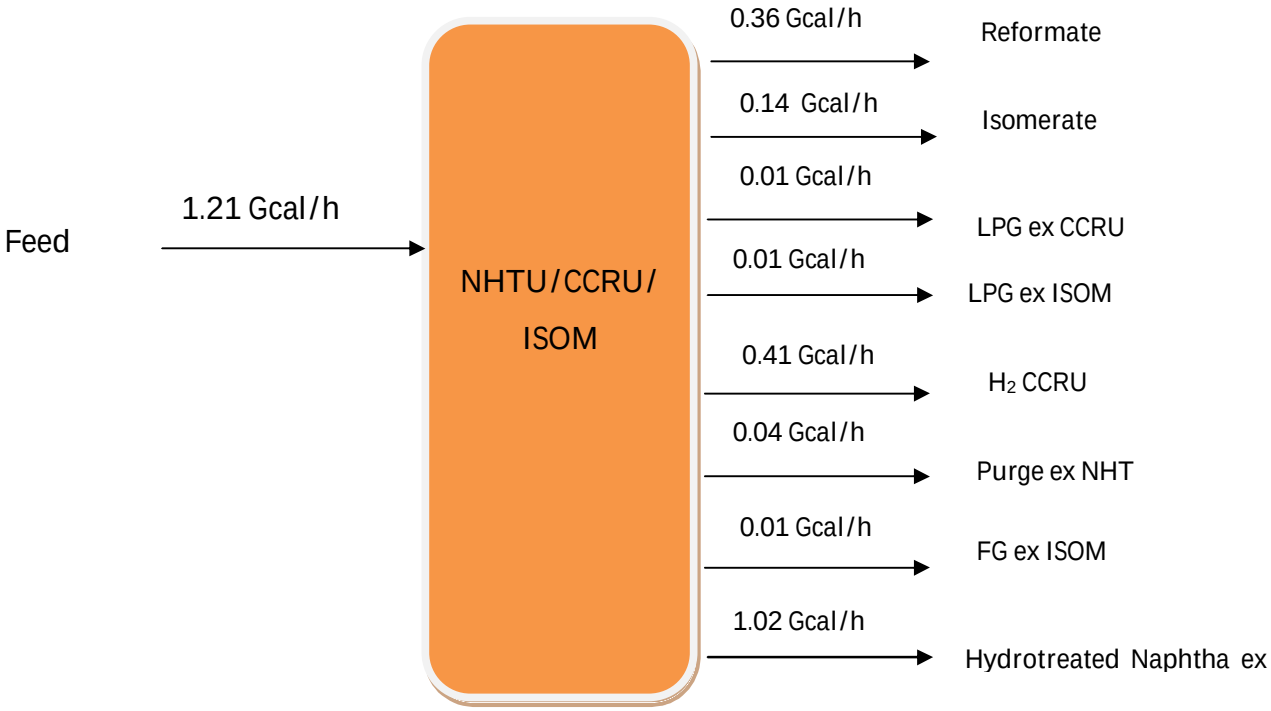
3.4.4.1. Material Balance for New Isomerisation Units

Material Balance for CCR Unit is given in following Table: 3.7 and the energy balance is given in Figure 3.13.

Table 3-7 Material Balance for NHTU, CCRU and ISOM

Description	Quantity in TPH	%wt
Input		
Feed	75	100
Output		
Isomerate	18.5	24.63
Reformate	35.2	46.96
H2 ex PSA	1.2	1.64
LPG	0.7	0.95
Off gases	0.9	1.25
Naphtha	18.4	24.58
TOTAL	75	100

Figure 3-13 Energy Balance for ISOM/CCRU/NHTU



3.5. Details of Crude Transportation

Mathura Refinery receives Crude Oil from Salaya through "Salaya-Mathura Pipeline" (SMPL) directly into the Crude Oil Tanks in the refinery. Imported Crude Oil from different sources and Bombay High Crude Oil is received in Crude Oil Storage Tank.

3.6. Final Products Slate after QIP

There is no change in the product slate or increase in production capacity after the quality improvement program. The list of products and quality is presented in Table 3.8.

Table 3-8 Product Details before and Post QIP

Product	Production Capacity (Thousand MTPA)	
	Before QIP	Post QIP
Gasoline	1153	1,298
Diesel	2858	2,858
Others	4411	4,280
Total	8422	8,436

3.7. Sulphur Balance in the Facility – Post Project Scenario

There will not be any major change in sulphur balance after QIP. Sulphur is mainly in two different forms mainly in the elementary sulphur and SO_2 emissions. Sulphur is mainly present in the crude oil, Natural gas which is used as fuel for furnaces and boilers and Power Plant.

Sulphur will be mainly removed in Sulphur Recovery Unit (SRU) in the form of elemental sulphur. The main objective of QIP is removal of sulphur in the fuel (product) thereby decreasing the sulphur emissions from the vehicles. The product quality after QIP is presented in the Table 3.9. The sulphur balance in the proposed facility is presented in the Figure 3.14. Details of Sulphur present in the fuel (used for furnaces), Power Plants are presented in Table 3.10 and 3.11. Sulphur recovered in the SRU and emissions from stack are presented in Table 3.12.

Table 3-9 Quality of Fuel before and Post QIP

Product type	Bharat Stage IV Sulphur in PPM	Bharat Stage VI Sulphur in PPM
Gasoline	50	10
Diesel	50	10

Figure 3-14 Sulphur Balance in the Proposed Facility

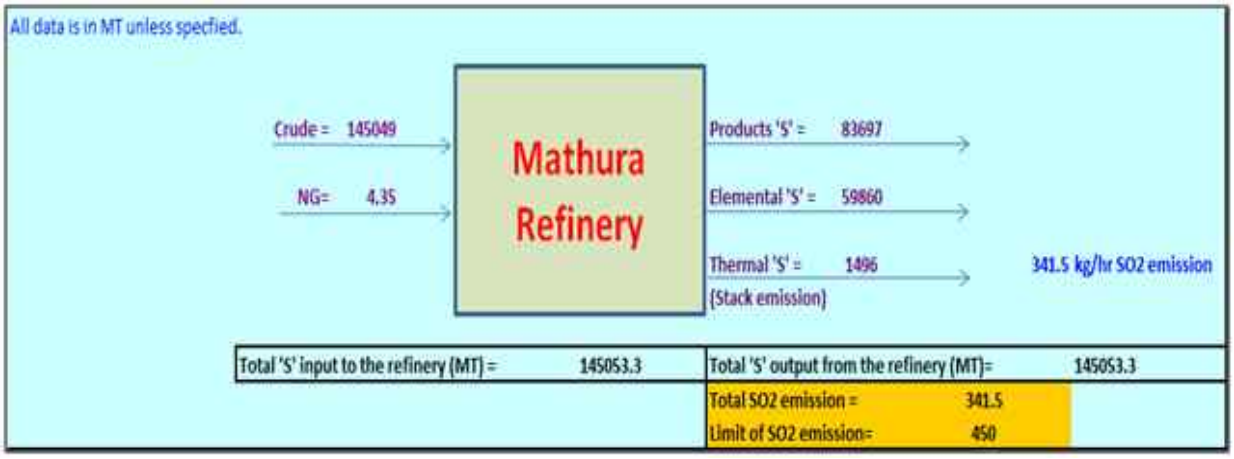


Table 3-10 Sulphur Content in the Fuels Used in Furnaces for Existing and Post QIP

Source	Sulphur -Inputs		Sulphur -Outputs	
	Existing	Proposed	Existing	Proposed
Crude	145049	145049	NA	NA
NG firing in furnaces and boilers etc	4.21	4.35	NA	NA
Product	NA	NA	84065	83697
Elemental S recovered	NA	NA	59500	59860
Thermal S into stack	NA	NA	1488	1496
Total	145053.2	145053.3	145053.2	145053.3

Table 3-11 Sulphur Content of Fuel Used in Power Plants for Existing and Post QIP

Post QIP					
Name of the Furnace/Boiler	Type of fuel	Quantity MT/A	Sulphur content	UOM	Total Sulphur (MT/A)
TPS, GT	FO	7357	1	%	72.8
	FG	9311	150	ppm	1.397
	NG	278015	10	ppm	2.78
				Total	77.0
Furnace	FO	30643	1	%	303.4
	FG	255689	150	ppm	38.4
	NG	156985	10	ppm	1.6
	Coke	47000	1.7	%	817.8
Existing project					
Name of the Furnace/Boiler	Type of fuel	Quantity MT/A	Sulphur content	UOM	Total Sulphur (MT/A)
TPS, GT	FO	6832	1.0	%	68.3
	FG	9205	150	ppm	1.3808

Post QIP					
Name of the Furnace/Boiler	Type of fuel	Quantity MT/A	Sulphur content	UOM	Total Sulphur (MT/A)
	NG	269067	10	ppm	2.6907
				Total	72.4
Furnace	FO	30168	1.0	%	301.7
	FG	252795	150	ppm	37.9
	NG	151933	10	ppm	1.5
	Coke	47000	1.7	%	817.8

Table 3-12 Sulphur Recovered in SRU and Stack Emissions for Existing and Post QIP

SRU No	Total Sulphur Input (TPA)		Sulphur Recovery (TPA)		Sulphur Emissions from stack (TPA)	
	Base case	QIP Case	Base case	QIP Case	Base case	QIP Case
SRU A/B/C/D	59560	59920	59500	59860	59.6	59.9

3.8. Details Proposed Stacks

In proposed project, Sulphur emissions from the stacks will be increased which is minimal for the revamp of DHDS, Prime G and installation of ISOM and CCR. The details of Sulphur emissions of stacks connected to units for Existing and Post project are presented in Table 3.13.

Table 3-13 Details of Sulphur emissions of stacks connected to units for Existing and Proposed Project

Stack (Limit – 450 kg/hr)	Existing operations	Post project scenario
	Kg/hr	Kg/hr
CDU	122.08	122.08
VDU	26.8	26.8
VBU-I,II	24.16	24.1
FCCCH	16.5	16.5
FCC-CO Boiler	61.1	61.1
BBU	1.08	1.08
SRU A/B/C/D	61.87	61.87
CRU-I	1.27	1.27
CRU-II	1.51	1.51
DHDS	0.26	0.263
OHCU-I	0.18	0.18
OHCU-II	0.43	0.43
NHDT	0.05	0.05
HGU	1.75	1.75

Stack (Limit – 450 kg/hr)	Existing operations	Post project scenario
	Kg/hr	Kg/hr
Prime G	0.31	0.34
TPS & GTs	20.44	21.54
ISOM	-	0.05
CCR	-	0.48
TOTAL	339.8	341.5

3.9. Water Requirement after Post Project Scenario

There is no increase in raw water requirement after the post project scenario. At present the raw water requirement is 669m^3/hr. There is decrease in waste water discharge from 176m^3/hr to 169m^3/hr due to increase in waste water recycling. Fresh Water Requirement and waste water discharge for the existing and post project scenario is presented in Table 3.14 and water balance diagram is presented in Figure 3.11.

Table 3-14 Water Requirement and Wastewater Discharge for Existing and Post Project Scenario

S.No	Category	Unit	Existing	Post QIP	Remark
1	Fresh Water Requirement	m^3/hr	669	669	No change in fresh water requirement
2	Wastewater discharge into river	m^3/hr	176	169	Increased wastewater recycling through new Filtration system at ELR.
3	Treated wastewater recycling	m^3/hr	402 (70 %)	413 (71%)	

3.9.1. Wastewater discharge

The wastewater generated from the facility is around 402 m^3/hr for the existing scenario and after 413 m^3/hr for post project scenario. There will be 7m^3/hr less discharge after post project scenario when compared to the existing scenario.

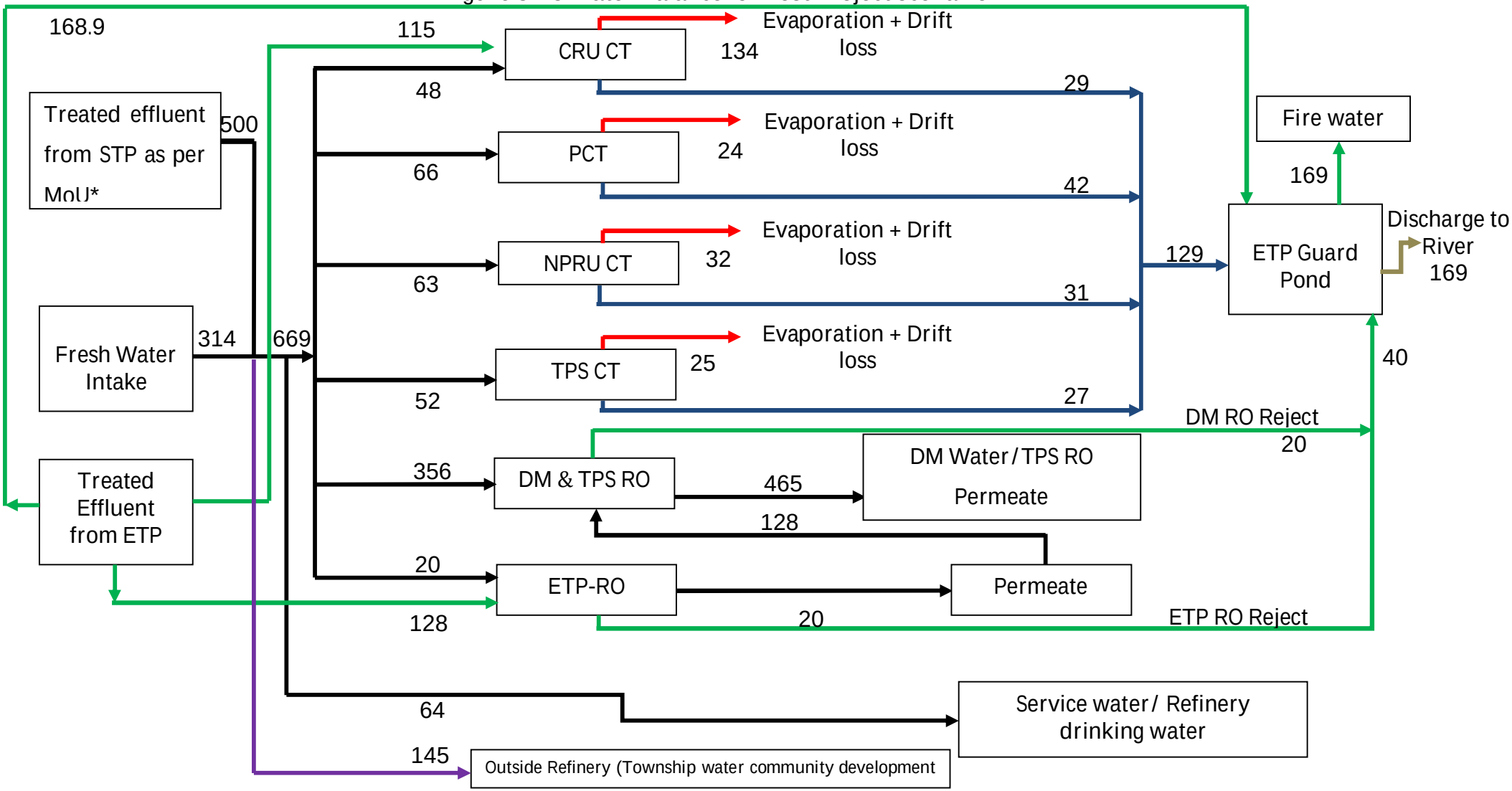
IOCL, Mathura is having the state of the art effluent treatment plant which is adequate to treat the effluent after post project scenario.

In order to contribute towards Namami Gange program, Mathura Refinery shall consider using the treated effluent from the STPs for their non-portable water requirement. For this

purpose a new STP is proposed by NMCG (National Mission for Clean Ganga), MoWR, RD & GR of approx. 20 MLD capacities, to the water requirements of refinery. A copy of STPs MoU is attached as *Annexure 12.* A new STP is also proposed on any advanced aerobic process capable to generate designed treated consistently required by the refinery. Treated effluent from STP will be only available after commissioning of STP at Mathura - Vrindavan Area . This project is being done by NMCG , Ministry of water resources , River Development & Ganga rejuvenation, Govt. Of India. However, MoU has been signed between Mathura refinery and MoWR, RD& GR on 17th aug,2016 for reuse of 20 MLD treated effleunt from STP.

Mathura Refinery is increasing the wastewater recycling from 402 m^3/hr to 413 m^3 /hr after proposed QIP.

Figure 3-15 Water Balance for Post Project Scenario



**Remarks: Treated effluent from STP will be only available after commissioning of STP at Mathura - Vrindavan Area which is being done by NMCG , Ministry of water resources , River Development & Ganga rejuvenation, Govt. of India. However, MoU has been signed between Mathura refinery and MoWR, RD& GJ on 17th aug,2016 for reuse of 20 MLD treated effluent from STP.*

3.10. Solid and Hazardous Waste

The expected solid wastes generation in the proposed project are hazardous and non-hazardous in nature. The main hazardous waste is spent catalyst and the time cycle for generation of spent catalyst will be three to ten years depending on the process. Details of solid and hazardous waste are presented in Table 3.15. The hazardous waste authorization was obtained from UPPCB for the disposal and the renewal of the hazardous waste authorization is under progress and the copy of the submission of renewal acknowledgment is enclosed as Annexure 13.

Table 3-15 Solid and Hazardous Waste Generation for Proposed Project Scenario

S. No	Type of Waste	Category	Existing (MT/year)	Incremental(MT/Year)	Post Project(MT/ Year)	Current Disposal Method
1	Spent Catalyst	1.6	200-250	46.5	246.5-296.5	Disposed through CPCB approved agency

3.11. Power Requirement

Existing facility required 67.3MWH power and the proposed QIP requires additional of 5.9MWH. IOCL, Mathura is having its own CPP which will source the power to all its units. The Existing CPP (steam turbine: 3 x 12.5 MW; gas turbine with: 3 x 20.2 MW) is adequate for quality improvement program.

3.12. Project cost

Total capital requirement for the modifications proposed under Quality Improvement Project (QIP) are Rs. 1713 crore based on April, 2015 prices with accuracy +/- 30%. The financial cost is worked out based on debt equity ratio 1:1.

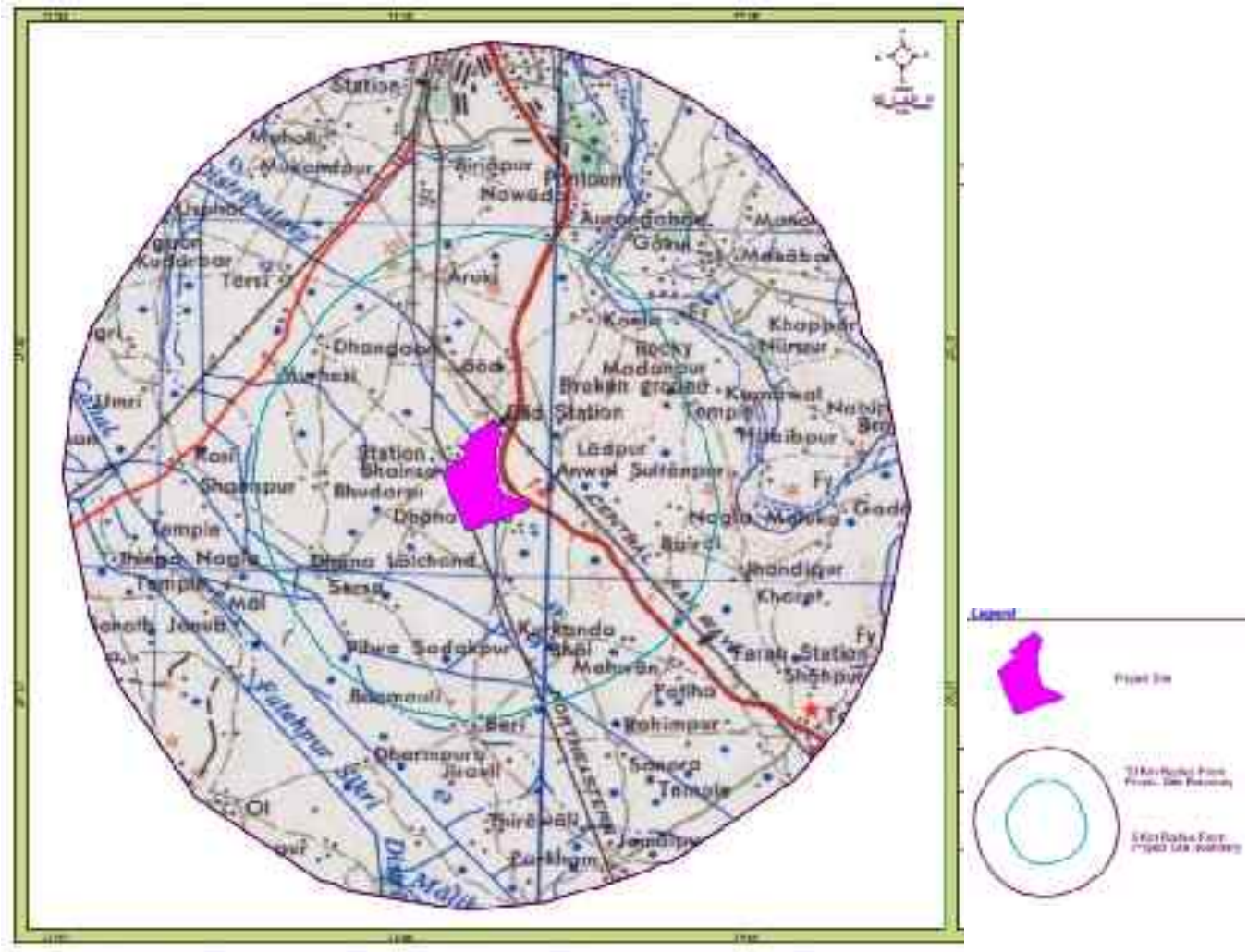
As the proposed project is to improve quality of products hence, internal rate of return cannot be estimated

4. DESCRIPTION OF THE ENVIRONMENT

4.1. Introduction

This chapter illustrates the description of the existing environmental status of the study area with reference to the prominent environmental attributes. The study area covers 10 km radius around the boundaries of the proposed Project site. The Topo map showing the project site is given in Figure 4.1.

Figure 4-1 Map showing the Study Area



The project site is located at Bhainsa village, P.O Mathura Refinery, Mathura District, Uttar Pradesh. Being a revamp project and with availability of adequate land with basic infrastructure within the existing plant site, no other alternative sites have been considered. The plant site is well connected to road and rail network. National Highway (NH-2) which connects from Delhi to Howrah passes through the site; railway line also

passes through the site with nearest station as Baad - almost adjacent to north corner of refinery complex or marketing terminal. However, the nearest railway junction – Mathura Railway Station is around 12 km from the site. The nearest airport is Kheria Airport at Agra, which is around 40 km from the site. The co-ordinates of the marketing terminal lies between 27˚23'41.04''N to 27˚28'8.06''N and 77˚ 40'33.13''E to 77˚40'55.40''E. The study area is covered by Toposheet No. 54 E11 and 54 E15.

4.2. Scope and Methodology of Conducting Baseline Study

The existing environmental setting is considered to adjudge the baseline environmental conditions, which are described with respect to climate, hydro-geological aspects, atmospheric conditions, water quality, soil quality, vegetation pattern, ecology, land use and socio-economic profile of the people.

As per the ToR File no. J-11011/151/2016-IA II (I) dated 23rd September 2016, the primary baseline data monitored covered three (3) months i.e., from 25th November 2016 to 23rd Febrauary 2017 and secondary data was collected from Government and Semi-Government organizations. The primary baseline data has been generated by Ind Research and Development House Pvt Ltd, Noida, an NABL approved Environmental Testing Laboratory.

An area, covering a 10 km radial distance from the project site is considered as the study area for the purpose of the baseline studies. As part of Environmental and Social Impact Assessment, this study was undertaken for a period of three month, from 25th November 2016 to 23rd February 2017. Primary data on Water, Air, Land, Flora, Fauna & Socio-Economic data were collected by a team of Engineers and Scientists. Secondary data was collected from various Departments of State/Central Government Organizations, Semi-Government and Public Sector Organizations. Table 4.1 gives various environmental attributes considered for formulating environmental baseline and Table 4.2 gives the frequency and monitoring methodology for various environmental attributes.

Table 4-1 Various Environmental Attributes

S.No.	Attribute	Parameter	Source of Data
1	Land Use	Trend of land use change for different categories	Topo sheet and Satellite imagery and ground truth verification
2	Ambient Air Quality	As per NAAQs standard parameter i.e, Particulate Matter (PM_{10} and $PM_{2.5}$), Sulfur dioxide (SO_2), Nitrogen dioxide (NO_2), Carbon Monoxide (CO), Ammonia (NH_3), Ozone (O_3), Lead (Pb), Benzene (C_6H_6), Benzo (a) Pyrene, Arsenic (As), Nickel (Ni)	Ambient air quality monitoring at eight locations
3	Water Quality	Physical, Chemical and Biological parameters	Water samples are collected at two surface water location and eight ground water locations during this study period
4	Noise levels	Noise levels in dB(A)	Noise level monitoring at eight locations
5	Ecology	Study of Existing terrestrial flora and fauna within the 10 km radius of project influence area through Quadrate and Line transact method for trees, shrubs and herbs, Point count method for birds, Belt transect method for road side trees and butterflies. Reconnaissance survey (Near Agricultural, Human habitations and Road side), identification of ecologically sensitive receptors based on literature survey and field investigations	Secondary sources and Field studies and Reconnaissance survey
6	Geology	Geological history	Secondary sources
7	Soil	Soil types and samples analyzed for physical and chemical parameters.	Data collected from secondary sources and soil sample analysis at eight locations

S.No.	Attribute	Parameter	Source of Data
8	Socio economic aspects	Primary Survey was undertaken at the designated villages to establish the existing socioeconomic status of the study area. Socioeconomic indicators such as demography, literacy, health and livelihood, amenities and cultural aspects were studied, Secondary Published data on population and amenities obtained from Directorate of Census Operations, GOI characteristics were collected	Based on field survey and data collected from secondary sources

Table 4-2 Frequency and Monitoring Methodology

Attributes	Sampling		Measurement Method	Remarks
	Network	Frequency		
A. Air Environment				
Particulate Matter (PM10)	Total 8 locations to represent both upwind, down wind and background concentrations as per the CPCB guidelines.	24 hourly, two days in a week and 12 weeks in a month	Gravimetric (High-Volume with Cyclone)	As per CPCB Standards under November 18th 2009 Notification for NAAQS
Particulate Matter (PM 2.5)			Gravimetric (High-Volume with PM10 Impactor)	
Oxides of Sulphur (SO_2)			EPA Modified West & Gaeke method	
Oxides of Nitrogen (NOx)			Arsenite Modified Jacob & Hochheiser	
B. Noise				
Hourly equivalent noise levels	Requisite locations in the project influence area	Once	Instrument : Noise level meter	IS: 4954-1968
C. Water				

Attributes	Sampling		Measurement Method	Remarks
	Network	Frequency		
Water Quality	Set of grab samples At requisite locations for ground and surface water	Once	Samples for water quality collected and analyzed as per IS : 2488 (Part 1-5) methods for sampling and testing of Industrial effluents Standard methods for examination of water and wastewater analysis published by American Public Health Association.	
D. Land Environment				
Parameter for soil quality: pH, texture, electrical conductivity, organic matter, nitrogen, phosphate, sodium, calcium, potassium and Magnesium.	Requisite soil samples be collected as per BIS specification within project influence area	Once	Collected and analyzed as per soil analysis reference book, M.L.Jackson	

4.3. Administration Setup of the Study Area District

Mathura district is a city in the North Indian state of Uttar Pradesh. It is situated along the banks of the river Yamuna is a district of Uttar Pradesh state of northern India. The historic town of Mathura is the district headquarters. The District is part of Agra division. Mathura is bounded on the northeast by Aligarh District, on the southeast by Hathras District, on the south by Agra District, and on the west by Rajasthan and northwest by Haryana state. Mathura district is an important pilgrimage centre of Hindus.

4.4. Land Environment

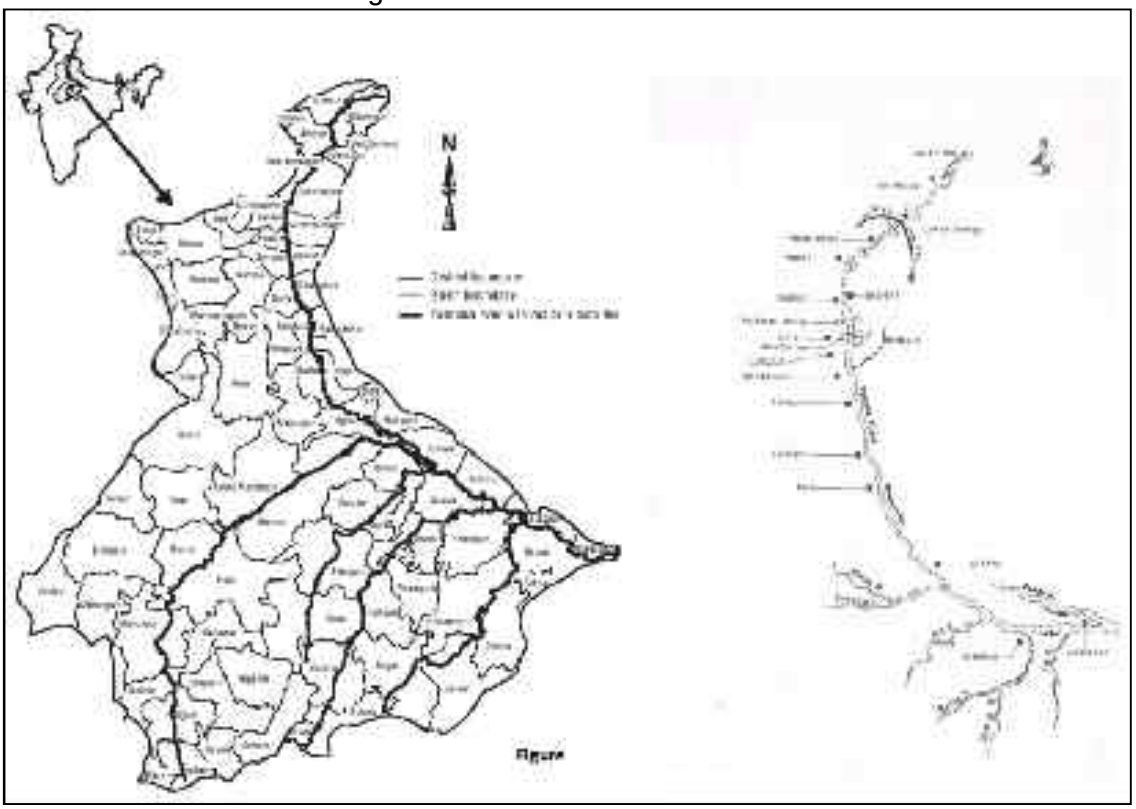
4.4.1. Drainage of the Region

Yamuna is the sub-basin of the Ganga river system. Out of the total catchment's area of 861404 sq km of the Ganga basin, the Yamuna River and its catchment together

contribute to a total of 345848 sq. km area which 40.14% of total Ganga River Basin (CPCB, 1980-81; CPCB, 1982-83).

River Yamuna is the largest tributary of the River Ganga. The main stream of the river Yamuna originates from the Yamunotri glacier near Bandar Punch (38°59' N, 78°27' E) in the Mussourie range of the lower Himalayas at an elevation of about 6320 meter above mean sea level in the district Uttarkashi (Uttranchal). The catchment of the Yamuna river system covers parts of the states of Uttaranchal, Uttar Pradesh (U.P.), Himachal Pradesh, Haryana, Rajasthan, Madhya Pradesh and the entire state of Delhi. The river Yamuna traverses a distance of about 1370 km in the plain from Saharanpur district of Uttar Pradesh to the confluence with river Ganga at Allahabad. The major tributaries of the river are Tons, Betwa, Chambal, Ken and Sindh and these together contribute 70.9% of the catchment area and balance 29.1% is the direct drainage of main River and smaller tributaries. On the basis of area, the catchment basin of Yamuna amounts to 40.2% of the Ganga Basin and 10.7% of the country

Figure 4-2 Yamuan River Basin



4.4.2. Land Use and Land Cover Study

Remote sensing satellite imageries were collected and interpreted for the 10 km radius study area for analysing the land use pattern of the study area. Based on the satellite data, land use/ land cover maps have been prepared.

Land Use / Land Cover - Land Use refers to man's activity and the various uses, which are carried on land. Land Cover refers to natural vegetation, water bodies, rock/soil, artificial cover and others, resulting due to land transformation. The present Land Use/Land Classification map is developed with following objectives. The main objective of the study is to classify the different land use within 10 km from the project boundary.

Information of land use and land cover is important for many planning and management activities concerning the surface of the earth (Agarwal and Garg, 2000). Land use refers to man's activities on land, which are directly related to land (Anderson et al., 1976). The land use and the land cover determine the infiltration capacity. Barren surfaces are poor retainers of water as compared to grasslands and forests, which not only hold water for longer periods on the surface, but at the same time allow it to percolate down.

The terms ' land use' and 'land cover' (LULC) are often used to describe maps that provide information about the types of features found on the earth's surface (land cover) and the human activity that is associated with them (land use). Satellite remote sensing is being used for determining different types of land use classes as it provides a means of assessing a large area with limited time and resources. However satellite images do not record land cover details directly and they are measured based on the solar energy reflected from each area on the land. The amount of multi spectral energy in multi wavelengths depends on the type of material at the earth's surface and the objective is to associate particular land cover with each of these reflected energies, which is achieved using either visual or digital interpretation. In the present study the task is to study in detail the land use and land cover in and around the project site.

4.4.2.1. Satellite Data

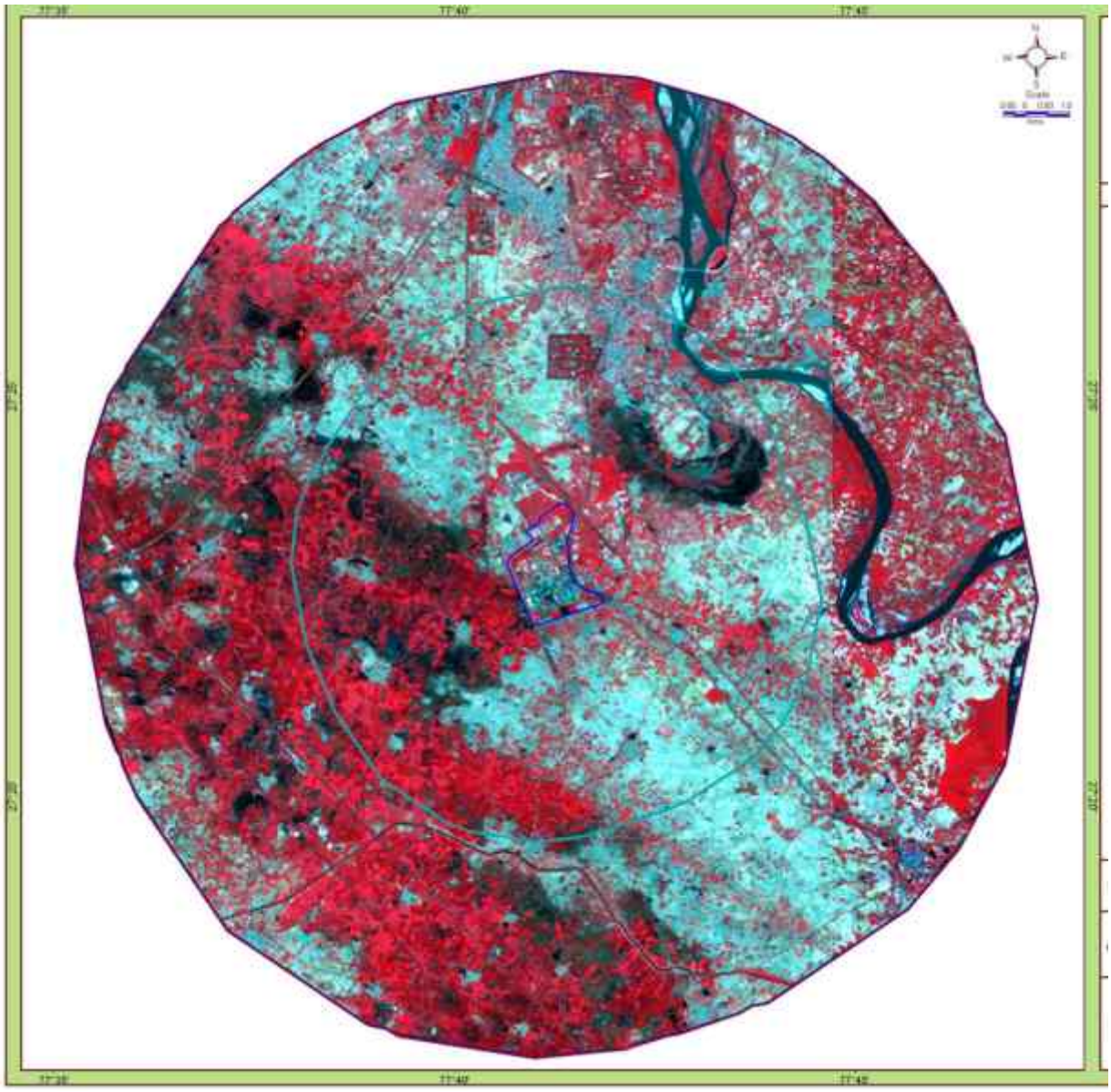
IRS Resourcesat-2 LISS-III multispectral satellite data of 06th February 2016 was utilized for the present study. Details of satellite data is given below. The rectification of imagery was carried out on to bring the digital data on the earth coordinate system by

means of ground control point (GCP) assignments/SOI Topo sheets. The details of the satellite data is given on Table 4.3

Table 4-3 Details of Satellite Data

Name of Satellite	Year	Sensor	Scale	Path & Row	Date of Pass
IRS-P6	2016	LISS III	1:50000	98-41	06-Feb-2016

Figure 4-3 Satellite imagery of the 10 km radius of the project site

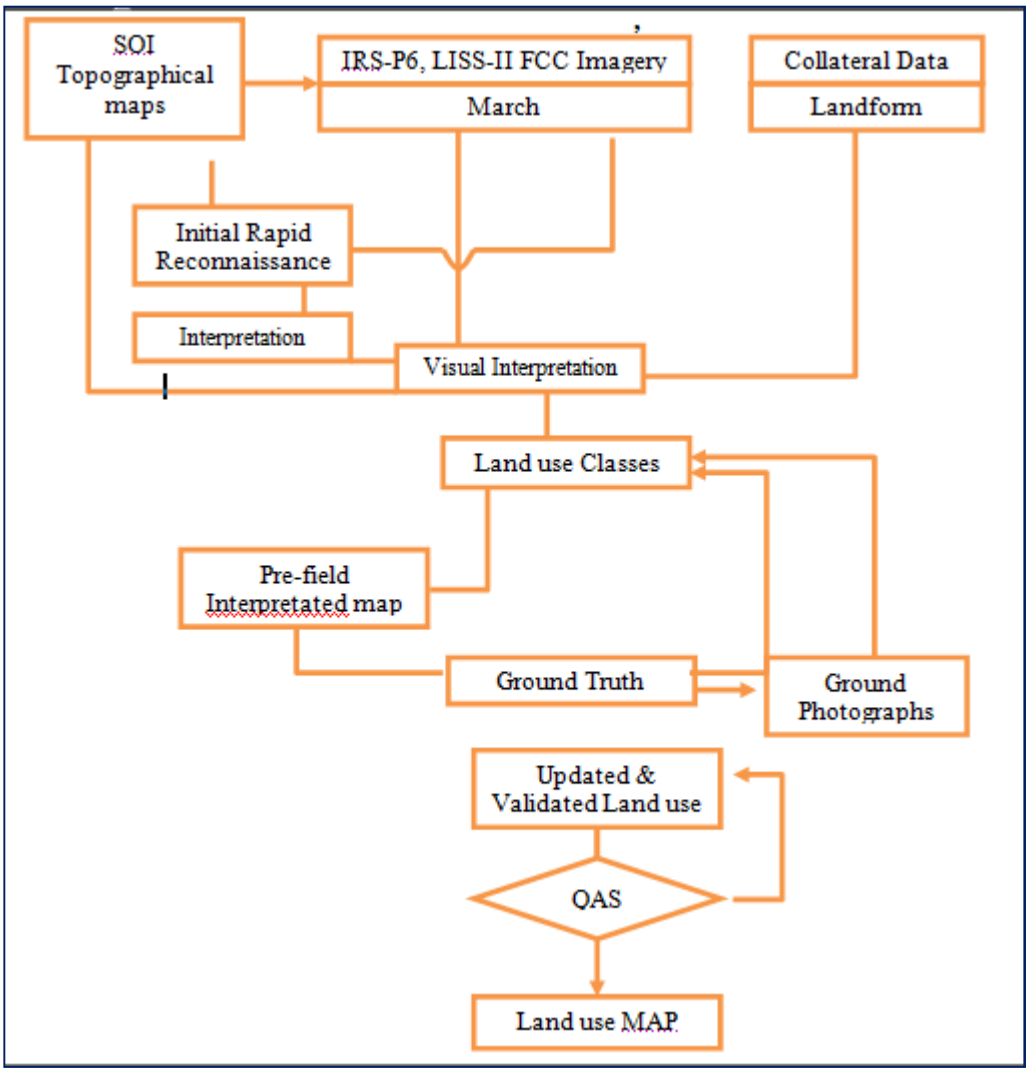


4.4.2.2. Methodology

Considering the user defined scale of mapping, 1:50000 IRS-P6, LISS-III data on 1:50000 Scale was used for Land use / Land cover mapping of 10 km radius for proposed site. The description of the land use categories for 10 km radius and the statistics are given

for 10 km radius.

Figure 4-4 Flowchart of Simplified Methodology



4.4.2.3. Interpretation Technique

Standard on screen visual interpretation procedure was followed. The various Land use / Land cover classes interpreted along with the SOI topographical maps during the initial rapid reconnaissance of the study area. The physiognomic expressions conceived by image elements of color, tone, texture, size, shape, pattern, shadow, location and associated features are used to interpret the FCC imagery. Image interpretation keys were developed for each of the LU/LC classes in terms of image elements.

March 2014 FCC imagery (Digital data) of the study area was interpreted for the relevant land use classes. On screen visual interpretation coupled with supervised image classification techniques are used to prepare the land use classification.

1. Digitization of the study area (10 km radius from the proposed site) from the topo maps.
2. In the present study the IRS –P6 satellite image and SOI topo sheets of 57-E/11, and 57-E-15 have been procured and interpreted using the ERDAS imaging and ARC-GIS soft ware adopting the necessary interpretation techniques.
3. Satellite data interpretation and vectorisation of the resulting units
4. Adopting the available guidelines from manual of LULC mapping using Satellite imagery (NRSA, 1989) .
5. Field checking and ground truth validation.
6. Composition of final LULC map.

The LULC Classification has been done at three levels where level -1 being the broad classification about the land covers that is Built-up land, agriculture land, waste land, wet lands, and water bodies. These are followed by level –II where built-up land is divided into towns/cities as well villages. The Agriculture land is divided into different classes such as cropland, Fallow, Plantation, while wastelands are broadly divided into, Land with scrub and without Scrub and Mining and Industrial wasteland. The wetlands are classified into inland wetlands, coastal wetlands and islands. The water bodies are classified further into River/stream, Canal, Tanks and bay. In the present study level II classification has been undertaken. The SOI Topo map is presented in Plate – 1 and Satellite imagery of 10 km radius from the project site is presented – Plate –2.

4.4.2.4. Field Verification

Field verification involved collection, verification and record of the different surface features that create specific spectral signatures / image expressions on FCC. In the study area, doubtful areas identified in course of interpretation of imagery is systematically listed and transferred on to the corresponding SOI topographical maps for ground verification. In addition to these, traverse routes were planned with reference to SOI topographical maps to verify interpreted LU/LC classes in such a manner that all the different classes are covered by at least 5 sampling areas, evenly distributed in the area. Ground truth details involving LU/LC classes and other ancillary information about crop growth stage, exposed soils, landform, nature and type of land degradation are recorded and the different land use classes are taken.

4.4.2.5. Land Use/Land Cover Classification System

The present land use / land cover maps were prepared, based on the classification system of national standards. For explanation of each of the land use category, the details as given in Table 4.4 were considered.

Table 4-4 Land Use/Land Cover Classification System

S. No.	Level-1	Level-2
1	Built-up Land	Town/cities
		Villages
		Institution/Industry/Godown etc
		Plotted Area/Layout
2	Agriculture Land	Crop Land
		Plantations
		Fallow
3	Forest	Evergreen/Semi evergreen
		Deciduous
		Forest Plantation
4	Wastelands	Rocky/Stony Waste
		Land with /without shrubs
		Saline/sandy & Marshy/swampy
5	Water Bodies	River/Stream
		Lake/Reservoir/Tanks
6	Others	Orchard/Other Plantation
		Shifting cultivation
		Salt Pans, Snow covered/Glacial
		Barren/Vacant Land

4.4.2.6. Final Output

Description of Land Use/Land Cover Classes

The following are the main interpreted land use/land cover classes of the study area and their respective areas are given in ha in Table 4.5 for the year 2016. The thematic map and land use pattern within 10 km and 5 km radius based on IRS Resource are shown in Figure 4.5 and Figure 4.6

Table 4-5 Level **1** Land Use/Land Cover Statistics of 10 Km Radius of the Study Area

S.No	Land use	Percentage	Area in Sq.Km
1	Crop Land	66.37	229.55
2	Plantation	1.34	4.63
3	Fallow Land	18.39	63.59
4	Built-up (Rural, Urban and	11.07	38.27

S.No	Land use	Percentage	Area in Sq.Km
	Industry)		
5	Forest Plantation	0.72	2.50
6	Water Body	2.11	7.31
	Total	100.00	345.86

Figure 4-5 The thematic map and land use pattern within 10 km and **5** km radius based on IRS Resource

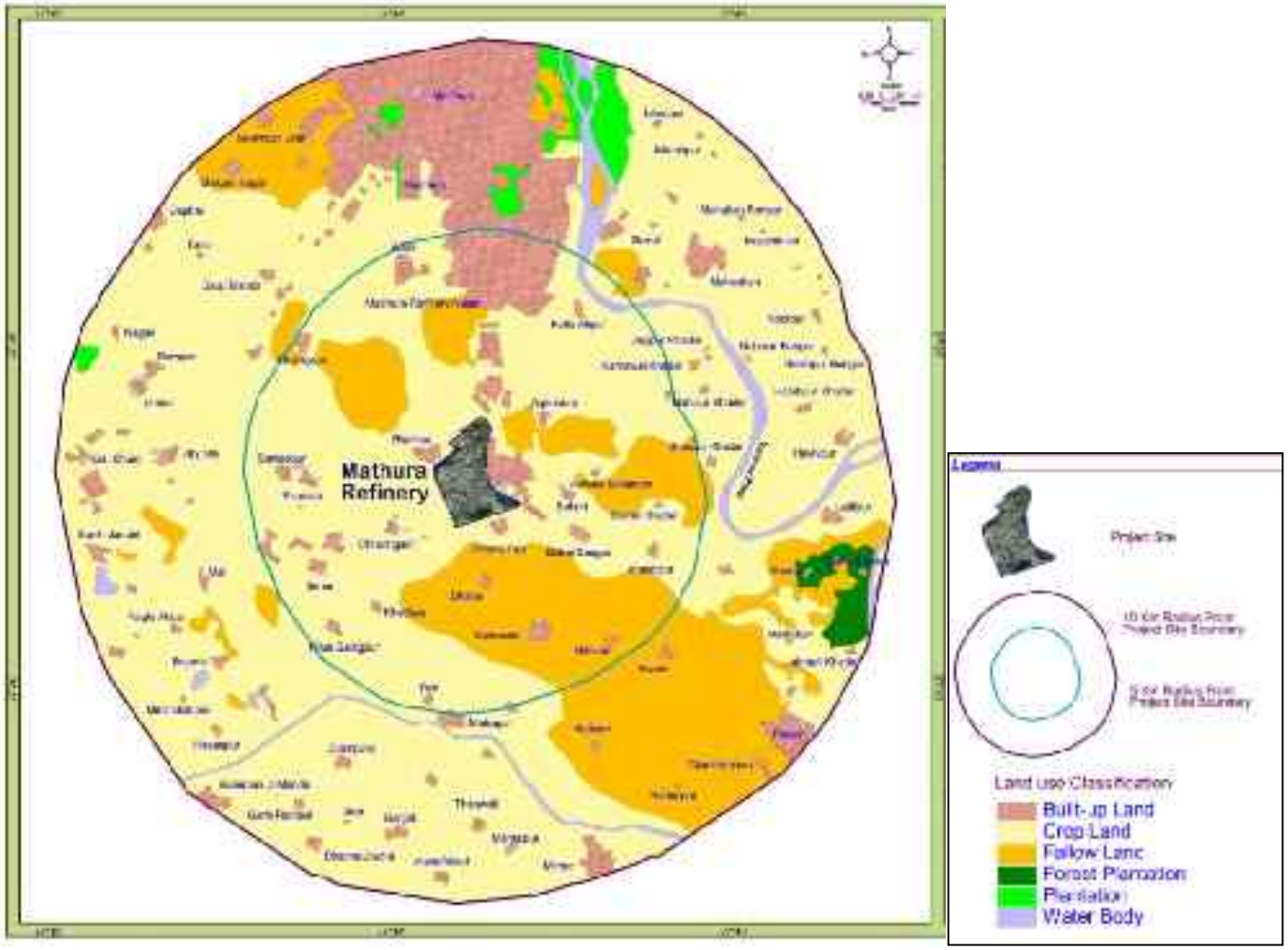
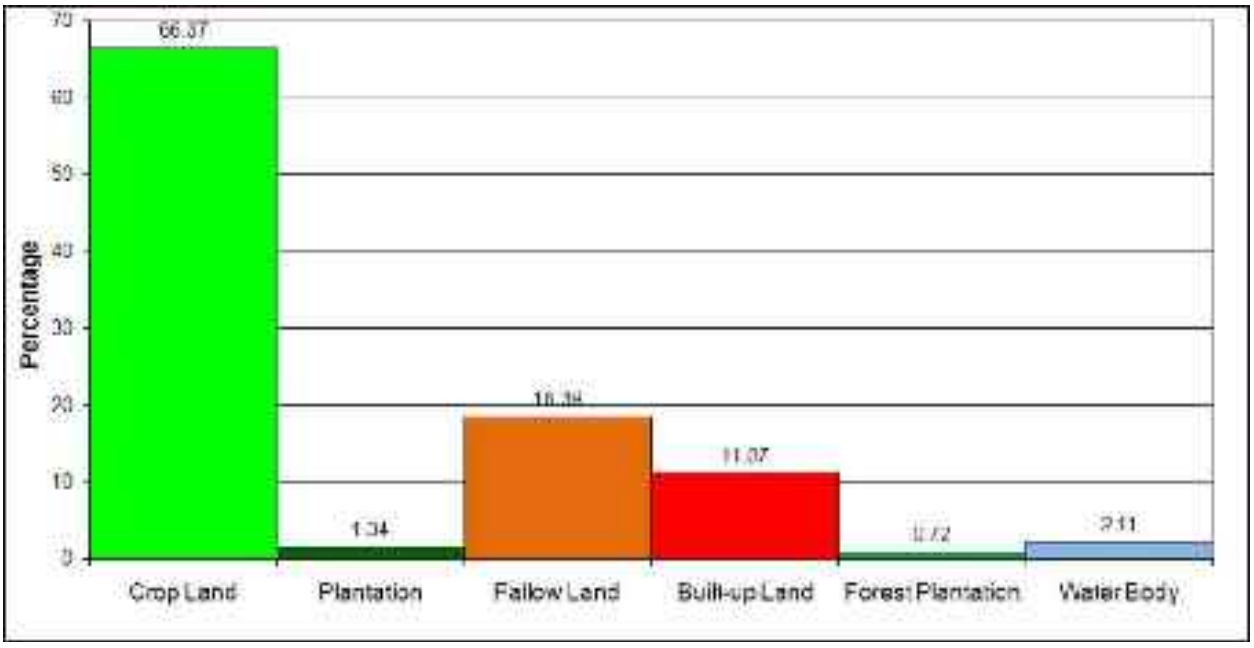


Figure 4-6 Distribution of LU/LC in 10 Km Radius Area – Level-I



The study reveals that the following major land use in the study area of 10 km radius from the project boundary

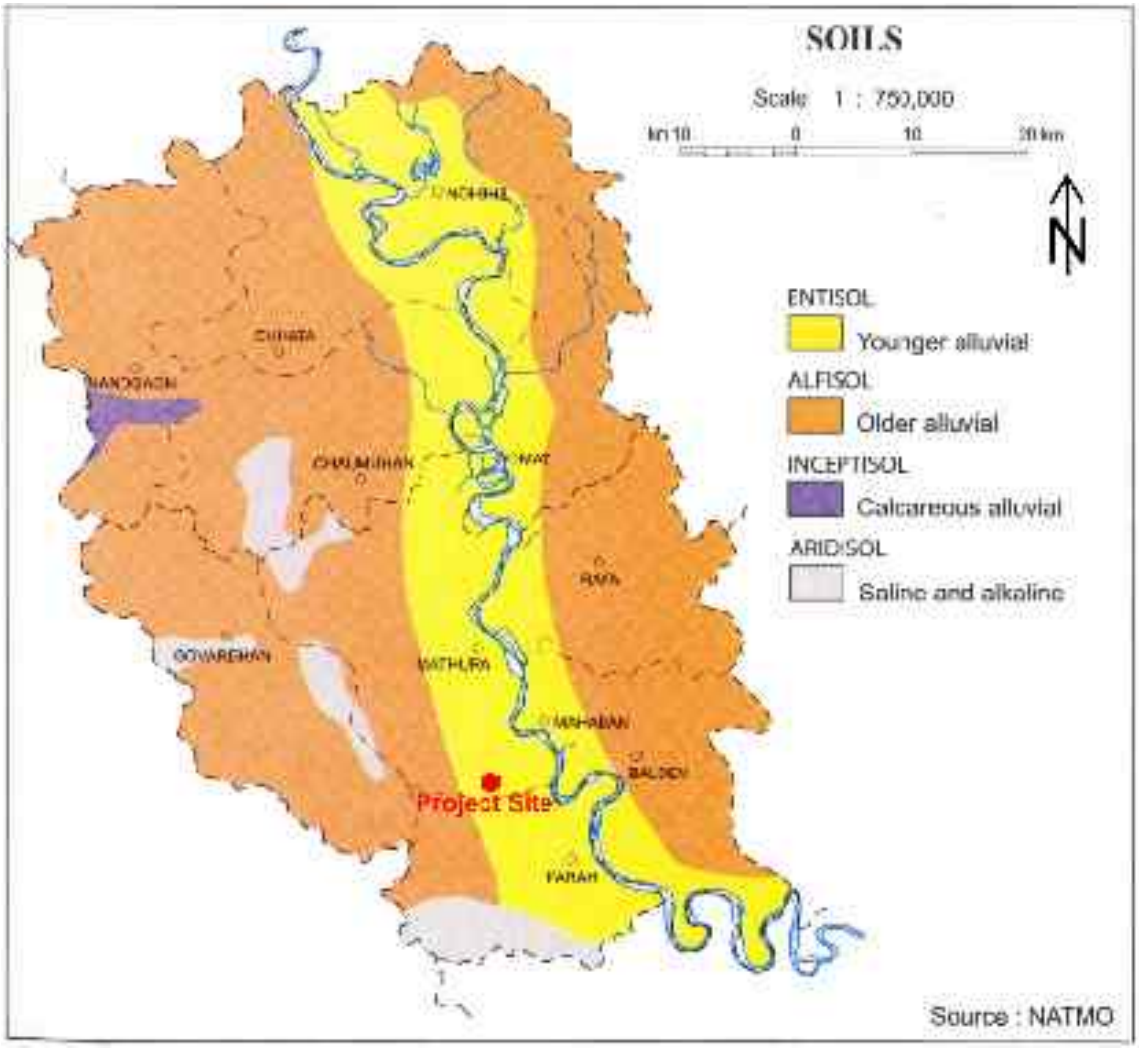
- In the agricultural land (Crop Land- 66.37) occupies majority of the area.
- About 25 % of the built up land is of Industrial nature.
- The Yamuna river flows in the eastern boundary of the study area occupy major area o the water body.
- The fallow land occupies about 18.39 % of the study area.

4.5. Geology and Soil Quality

4.5.1. Regional Geology and Soil Quality

The study area falls in the Northern plains of India in the Ganga basin. River Yamuna traverses the plain. The soil in the study area is generally older alluvial having high percolation rate resulting substantial recharge of groundwater. The hydrogeology is complex comprising hard rocks, semi-consolidated Cretaceous and tertiary formation, and unconsolidated alluvial deposits. Figure 4.7 shows the soil types in Mathura District.

Figure 4-7 Soil types in Mathura District

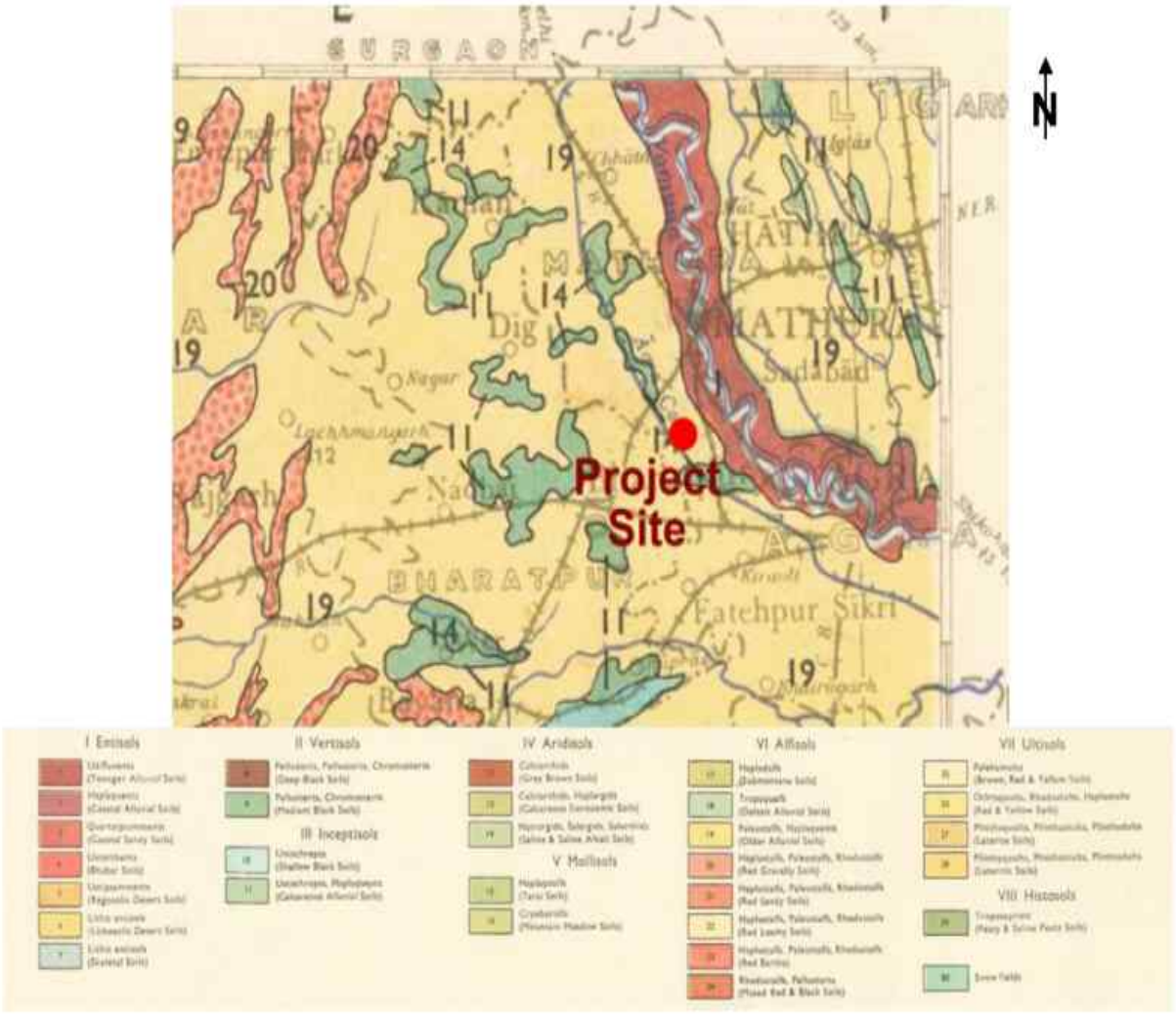


Source: National Atlas and Thematic Mapping Organization

4.5.2. Soil Type

The Figure below presents the soil regions of the study area. As per the map, the study area comprises of younger Alluvial Soils, near River Yamuna, Older Alluvial Soils and a few patches of Saline and Saline Alkali Soils. Soil type of the region is given in Figure 4.8

Figure 4-8 Soil Type

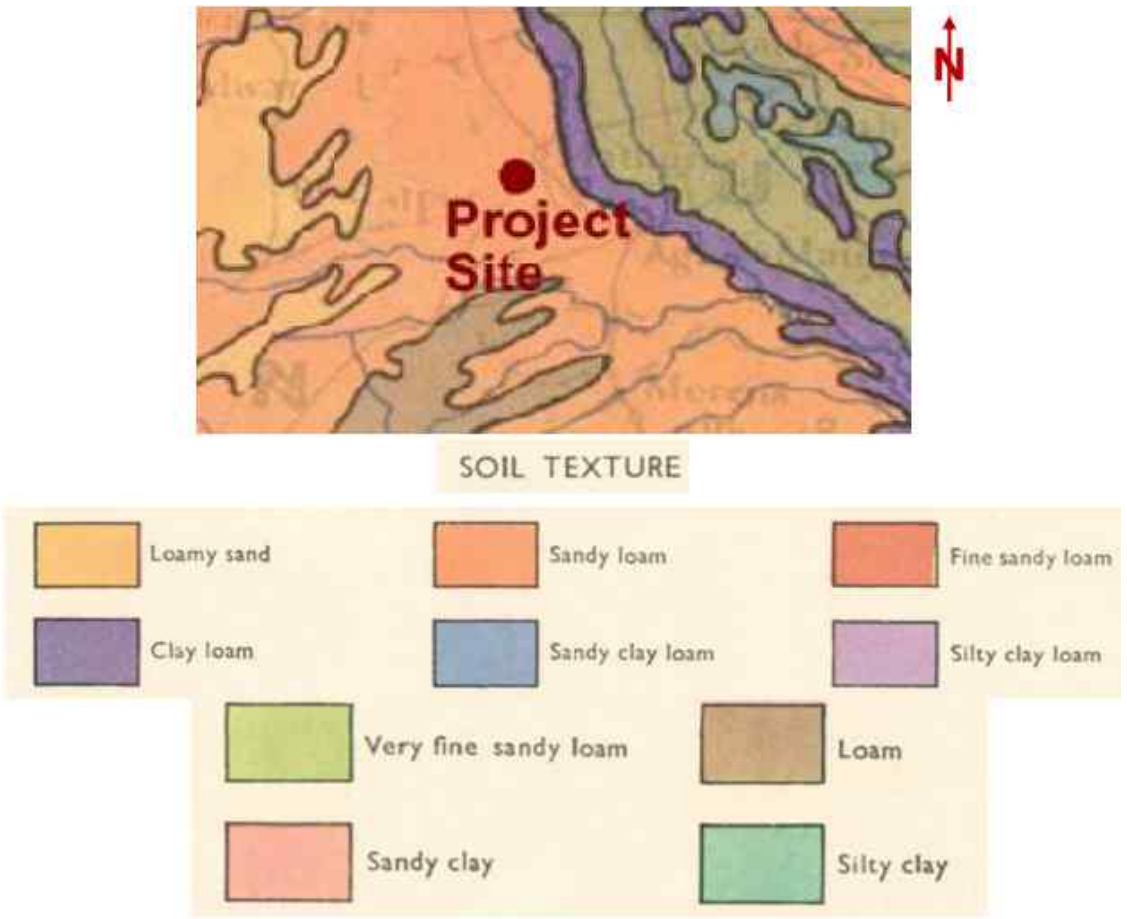


Source: National Atlas of India, Soil Regions – Western India – Plate 200

4.5.3. Soil Texture

The soils in the study area are generally sandy loam, clayey loam and loamy sand. Figure 4.9 presents the soil texture map for the study area.

Figure 4-9 Soil texture map for the study area.

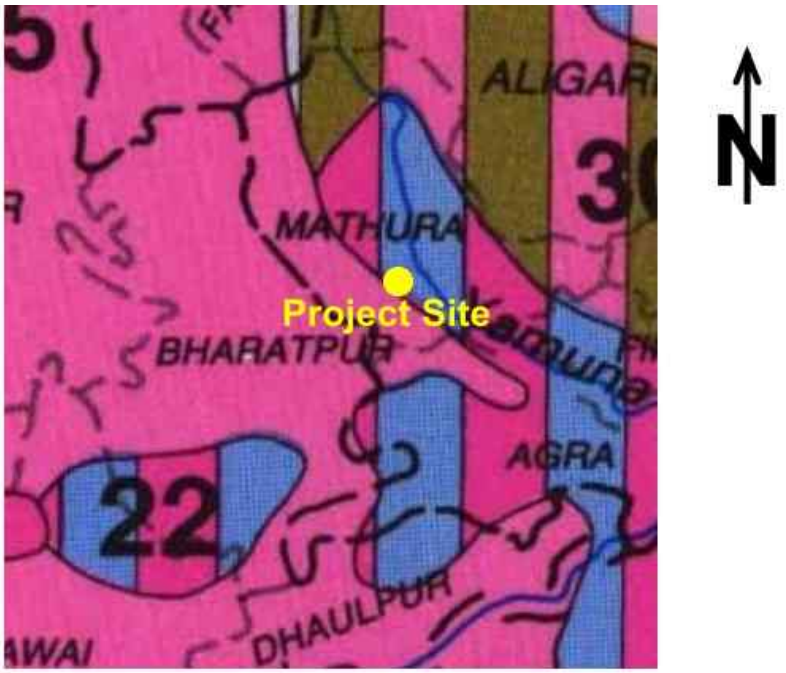


Source: National Atlas of India, India Soil Texture – Plate 58

4.5.4. Soil Degradation

The human induced soil degradation map (Figure 4.10) by National Bureau of Soil Survey and Land Use Planning, Nagpur indicates that the study area is characterized by water erosion with moderate loss of top soil affecting 26-50% area; high severity and water erosion with extreme terrain deformation affecting 26-50% area; and moderate loss of top soil affecting 11-25 % area; very high severity and moderate physical deterioration due to water logging affecting 11-25 % area; medium severity.

Figure 4-10 Soil degradation map



LEGEND

Map Unit symbol	Description	Area of mapped unit (million ha)	Area actually affected by degradation (million ha)
1	Stable terrain (Sn) showing water erosion (Wt) with slight loss of top soil, affecting 11-25% area; low severity.	5.1	0.9
2	Water erosion with slight loss of top soil, affecting 26-50% area; medium severity.	8.8	3.3
3	Stable terrain showing water erosion with slight loss of top soil affecting 6-10% area; low severity.	0.8	0.1
4	Stable terrain showing water erosion with slight loss of top soil, affecting 26-50% area; low severity.	31.7	11.9
5	Water erosion with moderate loss of top soil, affecting 26-50% area; high severity.	25.0	9.4
6	Water erosion with moderate loss of top soil, affecting 51-100% area; high severity.	74.4	55.8
21	Water erosion with strong loss of top soil, affecting 11-25% area, high severity; and moderate physical deterioration due to waterlogging, affecting 26-50% area; high severity	4.1	2.9
22	Water erosion with extreme terrain deformation, affecting 26-50% area; and moderate loss of top soil, affecting 11-25% area; very high severity and moderate physical deterioration due to waterlogging, affecting 11-25% area; medium severity.	3.1	2.3
23	Slight physical deterioration due to waterlogging, affecting 11-25% area; low severity; and water erosion with slight loss of top soil, affecting 26-50% area; medium severity.	6.4	3.5

Source: India Soil Degradation: Human – Induced by NBSS, 1994

4.5.5. Background Soil Quality in the Study Area

Soil samples were collected from eight locations within the study area out of which three locations falls within the refinery premises. The soil sampling locations are shown in Table 4.6. The soil samples were collected from 2 feet depth with the help of stainless steel soil – sampling probe and analyzed for Physico-Chemical parameters as per the Indian Standards.

Table 4-6 Details of Soil Sampling Locations

S.No	Location	Location Code	Source	Direction	Distance (km)
1	Sludge Disposal Area	S1	Soil sample from within the refinery premises used for disposal of waste sludge	North	0.5
2	Ecological Park	S2	Soil sample from green belt plantation area inside the refinery premises	South	0.2
3	Green Belt SE Direction	S3	Soil samples from green belt plantation area inside the refinery premises in South East direction	East	0.5
4	Dhana Teja	S4	Soil sample from Dhana Teja situated in south direction of refinery	South east	0.7
5	Baad	S5	Soil sample from Baad situated in north direction of refinery	North	3

Presentation of Results

The summary soil results of the analysis are tabulated in Table 4.7. The results are compared with the Standard soil classification which is given in Table 4.8. The results of the soil quality are presented in *Annexure-14.*

Table 4-7 Soil Analysis Results during Study period (25-11-2016 to 23-02-2017)

S.No	Test Parameters	S1	S2	S3	S4	S5
1	pH	8.11	7.93	8.32	8.01	8.11
2	Electrical conductivity, mS/cm	412.0	386.0	308.0	318.0	364.0
3	SAR	1.2	1.1	1.2	1.1	1.2
4	Available Nitrogen, %	0.096	0.064	0.080	0.072	0.052
5	Available Phosphorous, %	0.84	0.96	0.78	0.68	0.70
6	Available Potassium, %	0.02	0.008	0.020	0.010	0.014
7	Calcium as Ca, mg/Kg	64.0	72.0	68.0	70.4	76.2
8	Magnesium as Mg, mg/Kg	12.26	24.2	42.2	38.0	10.2
9	Sodium as Na, mg/Kg	0.0064	0.0086	0.0080	0.0096	0.0090
10	Organic matter (%)	2.1	1.8	2.2	2.1	2.3
11	Texture Classification	Sandy clay	Sandy slit	Sandy slit	Sandy slit	Sandy slit
12	Sand (%)	68.0	72.0	70.04	76.0	66.0
13	Clay (%)	18.26	12.20	10.08	8.26	9.20
14	Silt (%)	13.74	15.80	15.80	15.74	24.8

Table 4-8 Standard Soil Classification

Chemical Parameters	Ranking				
	Very Low	Low	Moderate	High	Very High
pH	<4, very Strongly Acidic	4-5, Strongly Acidic	5-8, Ideal for Plant Growth	8-9 Strongly Basic	>9 Very Strongly Basic
Electrical conductivity (µS/cm)	<2000, Non saline	2000-4000 Saline	4000-8000 Moderately Saline	8000-16000 Highly Saline	>16000 Extremely Saline
Total Nitrogen (%)	<0.05 Very Low	0.05-0.15 Low	0.15-0.25 Moderate	0.25-0.5 High	>0.5 Very High
Total Phosphorous (mg/kg)	<5 Very Low	5-10 Low	10-30 Moderate	30-60 High	>60 Very High
Sodium (mg/kg)	-	<200 Non Sodic	200-500 Moderate	>500 Sodic	
Potassium (mg/kg)	-	<150 Low	150-250 Moderate	250-800 High	>800 Very High
Calcium (mg/kg)	-	<1000 Low	1000-2000 Moderate	>2000 High	-
Magnesium (mg/kg)	<40 Very Low	40-100 Low	100-300 Moderate	>300 High	-
% Organic Matter	0.5-1.0 Very Low	1.0-2.0 Low	2.0-3.0 Moderate	3.0-5.0 High	>5 Very High

The bar chart showing the Texture classification and Nutrient content in the soil is given below in Figure 4.11 and 4.12.

Figure 4-11 Bar Chart Represents Texture Classification of the Soil Samples

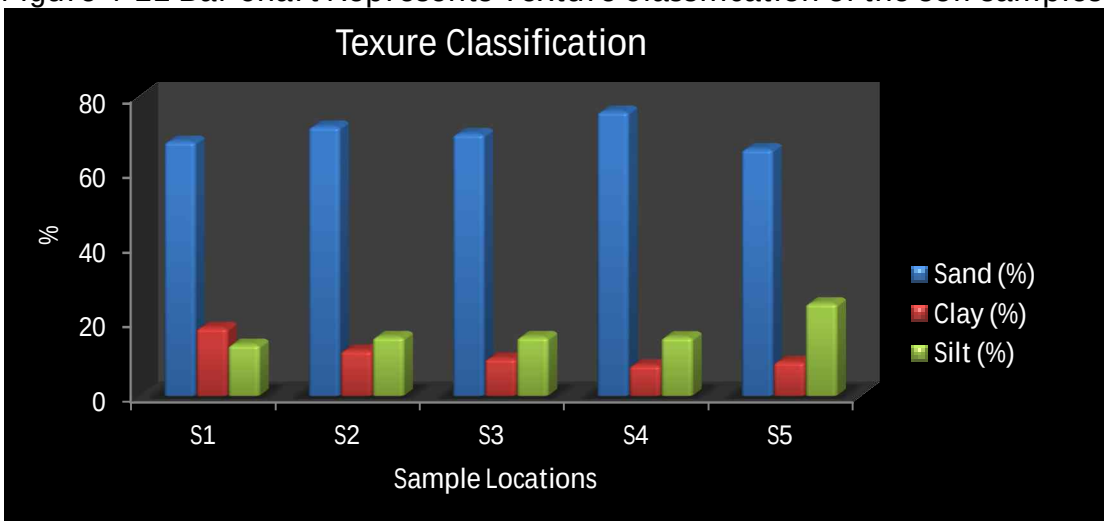
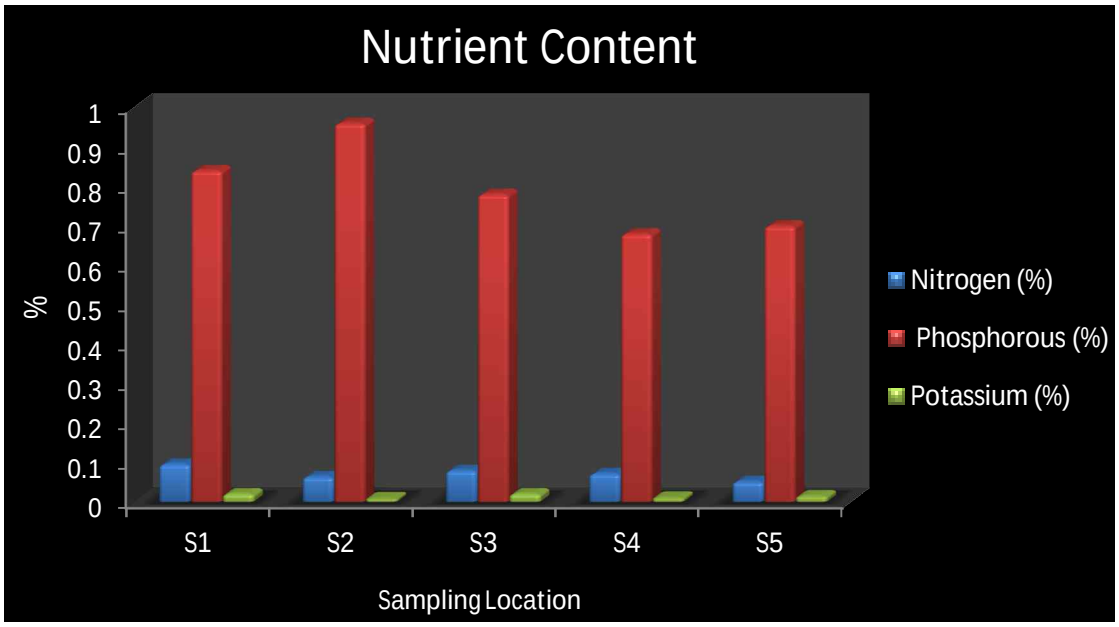


Figure 4-12 Bar Chart Represents Nutrient Content of the Soil Samples



4.5.6. Observations on Baseline Soil Status

The findings reveal that the texture is generally sandy clay in the S1 location and sandy silt in the remaining four locations with the water holding capacity ranging from 39% to 43%. Chlorides were found in the range of 490 mg/kg to 608mg/kg and the pH varying from 7.93 to 8.32. The organic carbon was found in the range of 1.8 % to 2.3% which is very low for supporting vegetation. As per the standard soil classification Nitrogen, potassium and Phosphorous of the soil indicates low content to support for vegetation which should be supplemented with chemical fertilizers for vegetative growth.

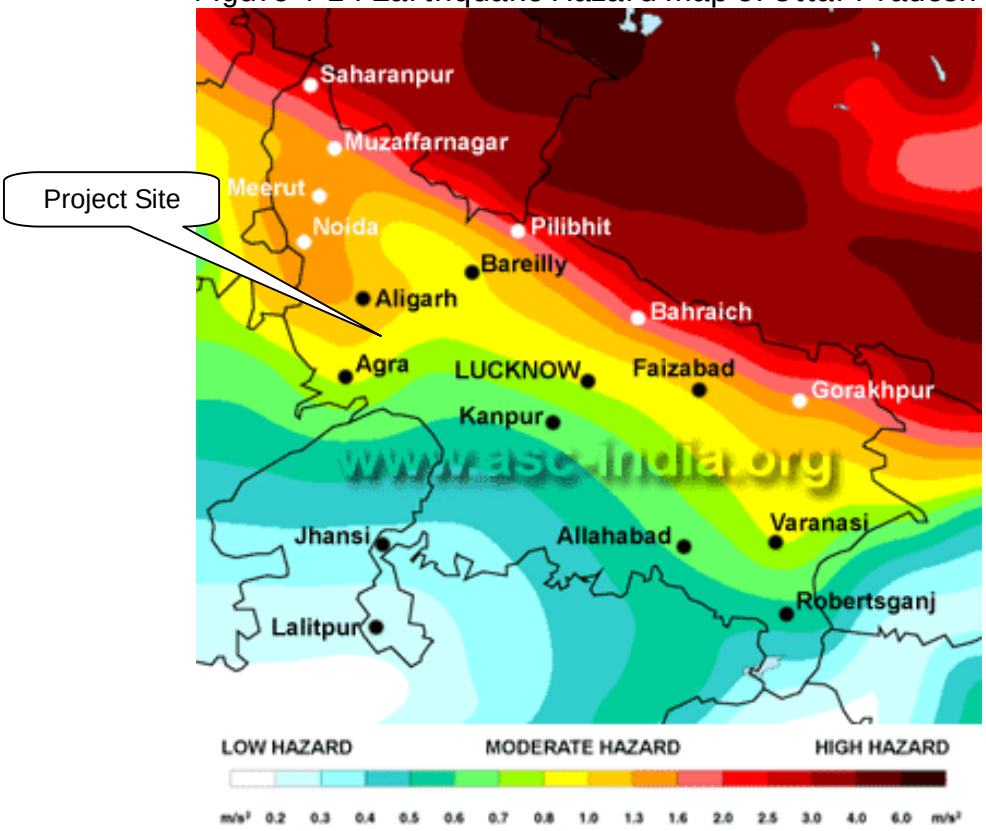
4.6. Seismic Zone

The project area falls under Zone IV of seismic zones of India as per the Maps of India, June 2014. According to GSHAP data, the state of Uttar Pradesh falls in a region of moderate to high seismic hazard. Historically, parts of this region have experienced seismic activity in the M5.0-6.0 range. The Seismic zone map of India and Uttar Pradesh is shown in Figure 4.13 and Figure 4.14 respectively.

Figure 4-13 Seismic Zone Map of India

Zone II – Least Active Seismic Zone
Zone III – Moderate Seismic Zone
Zone IV – High Seismic Zone
Zone V – Highest Seismic Zone

Figure 4-14 Earthquake Hazard map of Uttar Pradesh



Source: http://asc-india.org/maps/hazard/haz-uttar-pradesh.htm

4.7. Meteorological Data

Micro-meteorological data forms an important component of the Environmental Impact Assessment (EIA) study. As a part of the EIA study, both published long-term data and site specific meteorological data was collected as per the ToR (Terms of Reference) awarded for the proposed project. A meteorological station was installed within the project site to collect the site specific meteorological data.

4.7.1. Regional Climate and Meteorology – Indian Meteorological Department

The study area falls under "Semi Arid Zone" - according to Koppen's classification of climatic zones. These climates have hot, sometimes extremely hot summers, and mild to cold winters. The climate is wet during the monsoon and extremely dry during the rest of the year, with few or no months bringing moderate levels of precipitation. The nearest observatory of Indian Meteorological Department (IMD) is Mathura which is located at 9.5 km from the Refinery. Mathura Meteorology Observatory data was taken as reference point for verification of the primary meteorological data measured at Refinery. Table 4.9 shows the Published IMD Data from "Climatological Tables" for Mathura Observatory.

Temperature

The highest mean temperature was observed to be 45.4°C during June, and the lowest mean temperature was 2.8°C during January. The extreme highest temperature of 47.6°C was observed during June 1987 while the extreme lowest temperature of 0.5°C was observed during January 1978.

Rainfall

Data obtained from the Climatological Table shows that the maximum precipitation occurs from June to September. The maximum number of rainy days was found during August, and the average yearly rainfall for the study area was reported to be 633.3 mm with 36.5 rainy days.

Relative Humidity

The highest humidity of 79% occurs during July. The corresponding mean highest temperature was reported to be 40.3°C, and the corresponding mean lowest temperature was reported to be 22.8°C. The lowest humidity occurs in May during evening, and is reported to be 38%.

Wind Speed

The annual windrose (Figure 4.15) shows that the wind speed was found to be calm for 56 days in a year, while the remaining days it was found to vary from 1 kmph to 19 kmph. The predominant percentage (28%) of days, the winds were found to blow from North – West. Seasonal as well as annual wind rose diagrams are presented in Figure 4.15 and Figure 4.16 respectively.

Figure 4-15 Annual- Wind Rose (January to December) as per IMD Mathura Observatory Data

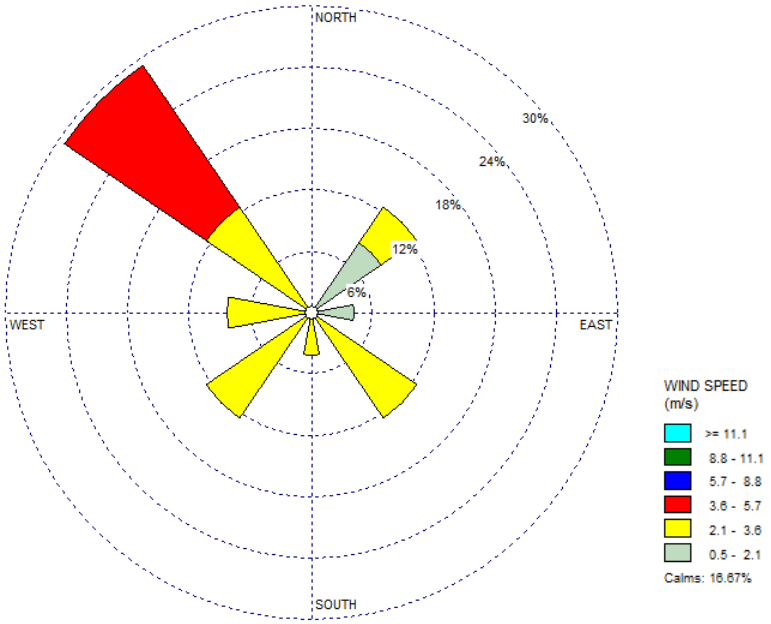
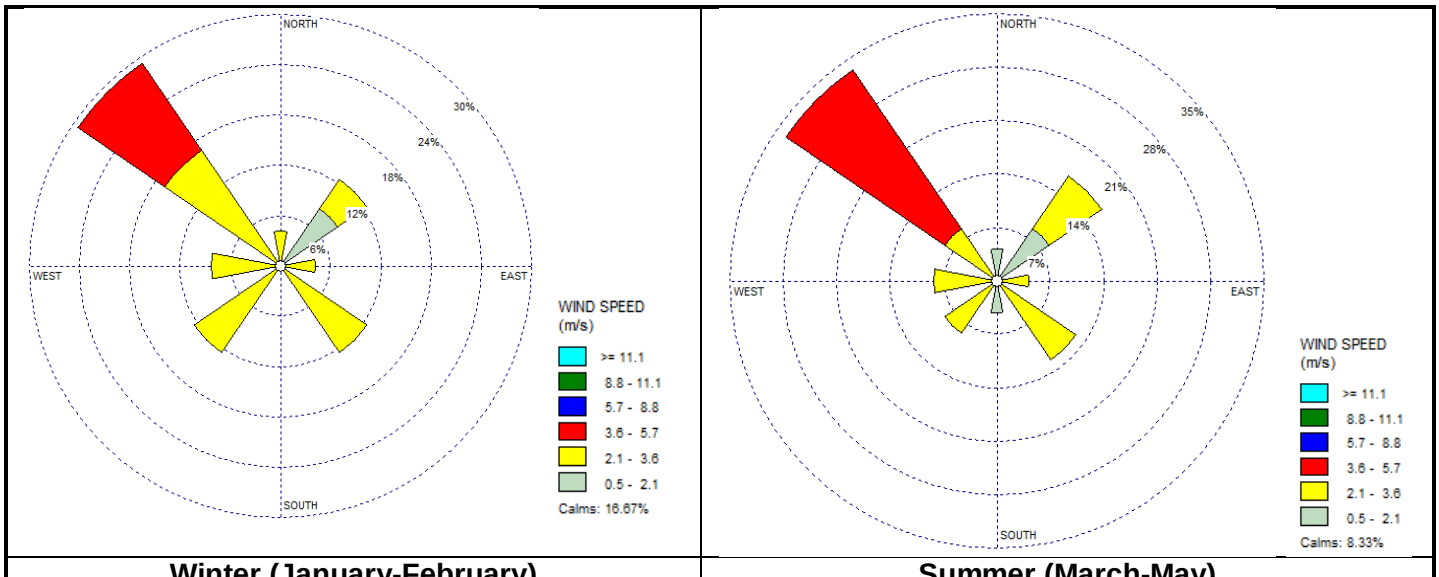
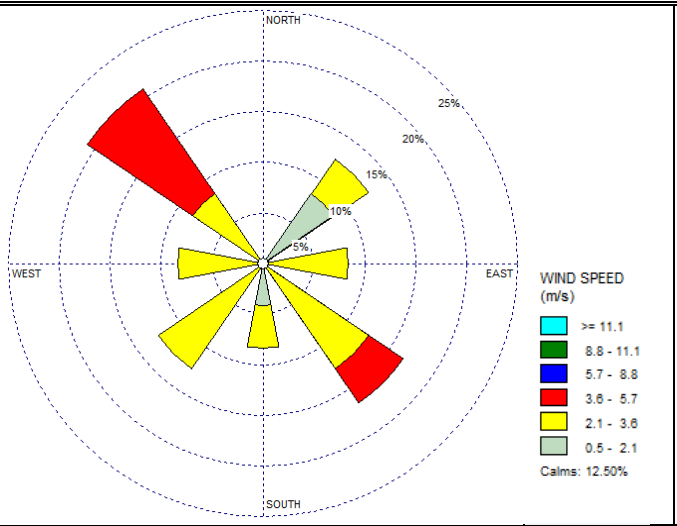


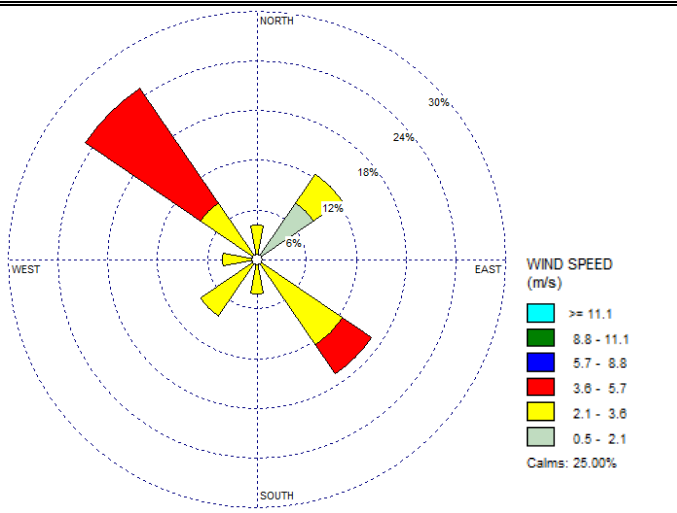
Figure 4-16 Windrose diagrams for various seasons as per IMD Mathura Observatory Data



Winter (January-February)	Summer (March-May)



South-West monsoon (June-September)



North-East monsoon (October-December)

Table 4-9 Indian Meteorological Department – Climatological Tables 30 Years Data: 1971-2000 Station: Mettur

Month	Temperature (ºC)				Humidity (%)	Rainfall (mm)			
	Mean		Extremes			Monthly Total	No. of Rainy days	Heaviest fall in 24 Hrs	Date and Year
	Highest	Lowest	Highest	Lowest					
Jan	25,5	2.8	29.6	1.0	70	11.9	1.1	39.0	
Feb	29.7	3.9	34.1	0.5	63	12.9	1.2	45.4	
Mar	35.6	8.6	40.1	5.0	57	6.9	1.1	17.6	
Apr	42.1	13.8	45.1	7.0	48	12.5	1.1	37.2	
May	44.8	18.5	47.1	8.5	42	21.3	2.1	36.0	
Jun	45.4	21.6	47.6	17.0	49	50.3	3.6	66.8	
Jul	40.3	22.8	44.6	11.5	75	161.0	9.1	99.4	
Aug	37.7	23.4	42.7	17.5	76	214.6	10.6	124.3	
Sep	36.9	20.4	40.6	17.6	74	90.3	4.5	99.8	
Oct	36.9	13.8	42.1	11.5	63	12.3	0.8	60.2	
Nov	33.1	8.1	35.1	4.0	62	3.4	0.3	24.0	
Dec	27.4	3.9	30.1	2.0	67	8.9	1.1	23.0	
Avg./ Annual Total	44.5	2.5	47.6	0.5	66	633.3	36.5	124.3	22, 1983

4.8. Site Specific Meteorological Data

The continuous weather monitoring station was installed near the project site at a height of 6m above the ground level and hourly measurements of the following parameters were measured at site during the study period i.e. from 25th November 2017 to 23th February 2017.

Wind speeds (m/s), wind direction (Degrees), Temperature (ºC), Relative Humidity (%), Rainfall (mm) etc were monitored.

Site Specific Ambient Temperature Profile (*25th November 2017 to 23th February 2017*)

The maximum mean ambient dry bulb temperature was observed in the study period was found to be 37 °C, whereas the minimum mean ambient dry bulb temperature of 6°C was observed in the study period.

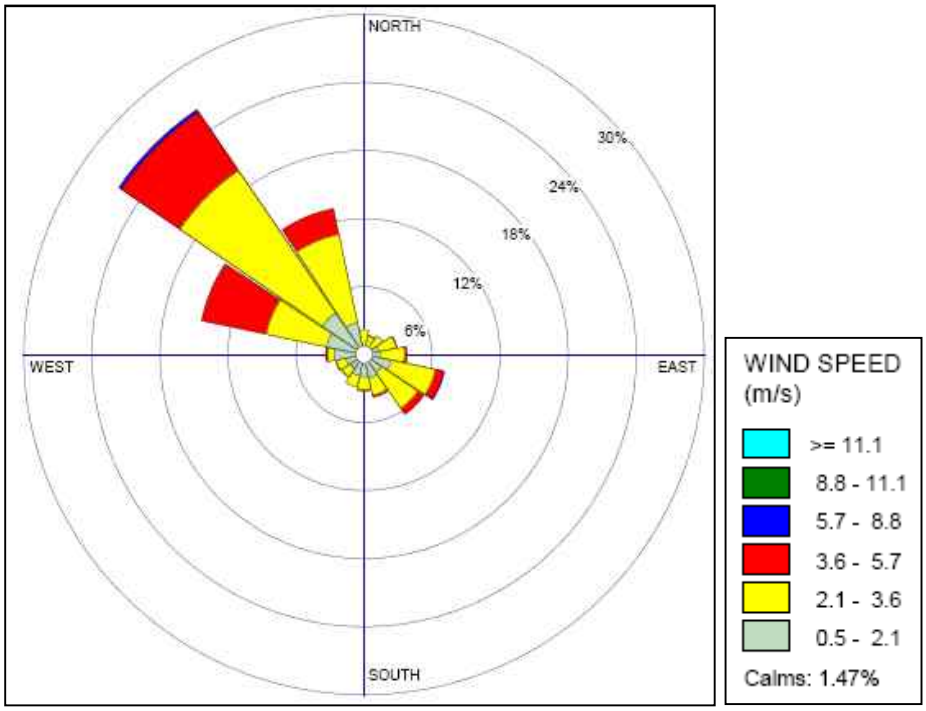
Relative Humidity (*25th November 2017 to 23th February 2017*)

The average hourly relative humidity variation at site during the study period was found to be 70 %.

Wind Direction and Wind Rose (*25th November 2017 to 23th February 2017*)

The predominant wind direction (Figure 4.) during the study period was from North-West. The average wind speed during the study period was about 2.4 m/s. The readings are in line with the IMD long term data.

Figure 4-17 Site Specific Wind Rose for the Study Period (*25th November 2017 to 23th February 2017*)



4.9. Ambient Air Quality Monitoring

The ambient air quality with respect to the study area of 10 km radius around the proposed project site forms the baseline information. Various sources of air pollution in the region are rural activities, traffic and industries. This will also be useful for assessing the conformity to standards of the ambient air quality during the plant operation. The

study area represents mostly rural environment. This section describes the selection of sampling locations, methodology adopted for sampling, analytical techniques and frequency of sampling.

4.9.1. Methodology Adopted for Air Quality Survey

Ambient Air Quality Monitoring Stations

The selection of the ambient air quality monitoring stations was done based on the CPCB guidelines and Environmental Impact Assessment Manual published by MoEF. The study area forms a typical rural background. The primary source of air pollution is industries present in the vicinity of project site. The secondary published data collected from the district census records indicated that there are no minerals and mining exploration facilities located in the study area.

The air quality monitoring stations were selected based on a screening air quality modeling exercise prior to commence of the study. Long-term meteorological data of nearest IMD station at Mathura for the specific seasons was adopted while estimating the possible impact zone due to emissions from the proposed facilities at the Project site. The regional meteorological data for November to February indicates the winds predominantly blow from North. Based on the findings of the screening air quality models, the impact zone is limited to 2 to 3 km from the proposed Project site beyond such a distance the pollutants would rapidly get diluted.

The ambient air quality monitoring of the study area (10 Km radius) was carried out during from 25th November 2016 to 23rd February 2017 at 8 locations as shown in Figure 4.18 and Table 4.10. Fine Dust Samplers of model NPM-FDS 2.5A was used for monitoring ambient air quality at all the identified locations within the stretch of 10 km from all four corners of the refinery. The following parameters as per the NAAQ standard has been monitored,

- Particulate Matter (PM10 and PM2.5)
- Sulphur dioxide (SO_2)
- Oxides of Nitrogen (NOx)
- Carbon Monoxide (CO)
- Lead (Pb)
- Arsenic (As)

- Nickel (Ni)
- Benzene (C_6H_6)
- Benzo Pyrene (BaP)
- Ammonia (NH_3)
- Ozone (O_3)

Figure 4-18 Ambient Air Quality Monitoring Locations

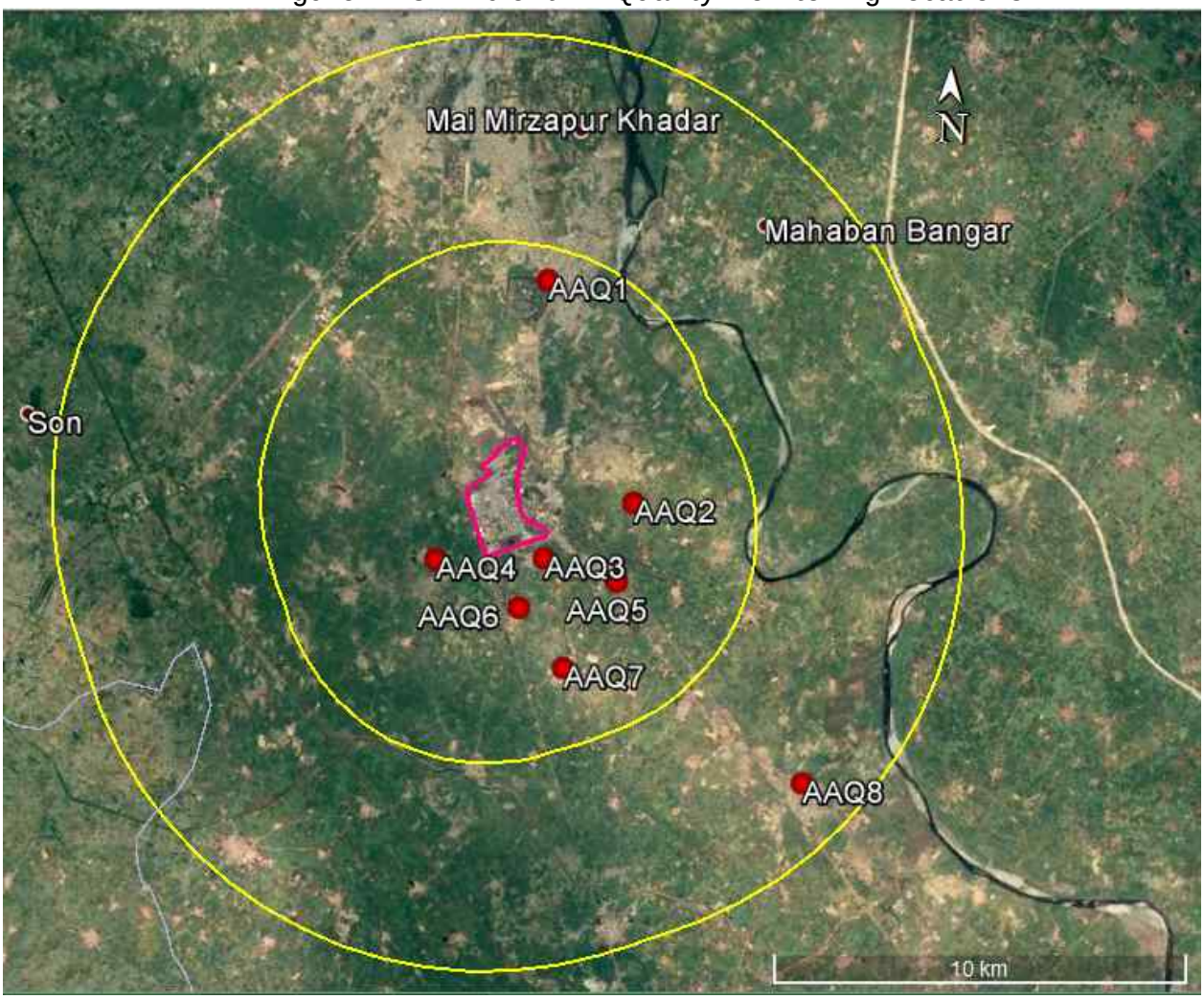


Table 4-10 Details of Ambient Air Quality Monitoring Locations

S.No	Stations	Name of Locations	Distance from plant site (km)	Direction	Environmental Setting	Site Coordinates
1	AAQ1	S.J. Hospital	4.3	N	Up wind direction – Sensitive area	27°25'45.6"N, 77°41'44.8"E
2	AAQ2	Gyasi Nagla	2.8	E	Cross wind direction – Residential (Rural area)	27°22'54.0"N 77°43'07.6"E
3	AAQ3	Dhana Teja	0.4	S	Down wind direction – Residential (Rural) area	27°22'08.1"N 77°41'50.7"E

S.No	Stations	Name of Locations	Distance from plant site (km)	Direction	Environmental Setting	Site Coordinates
4	AAQ4	Chharhgaon	2	SW	Cross wind direction – Residential (Rural) area	27°22'03.8"N 77°40'15.4"E
5	AAQ5	Barari	1.9	SE	Down wind direction- Residential area	27°21'52.0"N 77°42'55.4"E
6	AAQ6	Dhana Shamsabad	2.5	S	Down wind direction- Residential area	27°21'28.6"N 77°41'30.2"E
7	AAQ7	Bhahai	4	S	Down wind direction- Residential area	27°20'42.8"N 77°42'11.3"E
8	AAQ8	Farah	9.2	SE	Extreme down wind direction – Residential area	27°19'20.9"N 77°46'19.0"E

Figure 4-19 AAQ Monitoring Photographs


AAQ Monitoring at Nagla Gayasi Village


AAQ Monitoring Station at Chharhgaon

AAQ Monitoring Station at Bhahai

AAQ Monitoring Station at Farah

4.9.2. Presentation of Results

Ambient air quality monitoring was carried out at a frequency of two days per week at each of the identified location during study period (November 2016 to February 2017). The following criteria parameters were monitored according to the terms of reference and National Ambient Air Quality Standards as stated under MoEF Notification dated 16th November, 2009: (1) Particulate Matter (PM_{10}) (2) Particulate Matter ($PM_{2.5}$) (3) Sulphur dioxide (SO_2) (4) Nitrogen dioxide (NO_2) (5) Carbon monoxide(CO) (6). zone (O_3) (7) Lead (Pb) (8) Ammonia (NH_3) (9) Benzene (C_6H_6) (10) Benzo (a) pyrene (BaP) in Particulate Phase; (11) Arsenic (As) and (12) Nickel.

In addition to the above parameters hydrocarbon (methane and non methane) were also monitored as per the terms of reference issued for the project. The measured data was used for assessing for any anthropogenic impacts on the existing background levels.

The consolidated data of ambient air quality monitoring is shown in the Table 4.11 and Table 4.12 and test reports are presented in Annexure-15. It indicates that all the values are within the limits of National Ambient Air Quality Standards prescribed by Central Pollution Control Board.

Table 4-11 Summary of the Average Baseline Concentrations of Pollutants during Study Period *(25-11-2016 to 23-02-2017)*

S. No.	Location	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)	SO_2 (µg/m³)	NO_2 (µg/m³)	Pb (µg/m³)	CO (mg/m³)	O_3 (µg/m³)
1	S.J. Hospital	47.4	85.2	12.8	20.6	BDL (DL-)	1.4	37.9
2	Gyasi Nagla	49.6	89.7	13.1	22.0	BDL (DL-)	1.0	47.6
3	Dhana Teja	51.2	92.0	11.6	22.0	BDL (DL-)	0.9	25.7
4	Chharhgaon	50.3	79.5	14.9	21.6	BDL (DL-)	1.3	38.0
5	Barari	50.5	88.7	11.8	23.6	BDL (DL-)	0.9	35.1
6	Dhana Shamsabad	50.3	82.6	11.0	21.9	BDL (DL-)	1.5	35.0
7	Bhahai	49.0	89.2	10.7	21.3	BDL (DL-)	0.9	26.3
8	Farah	48.8	90.0	11.0	20.7	BDL (DL-)	1.6	25.4
9	NAAQ Standard for Industrial, Residential, Rural and Other area	60	100	80	80	1.0	2	100

Note: BDL is Below Detection Limit, DL is Detectable Limit

Table 4-12 Summary of the Average Baseline Concentrations of Pollutants during Study Period *(25-11-2016 to 23-02-2017)*

S.No	Location	Methane (µg/m³)	Non-Methane (µg/m³)	NH_3 (µg/m³)	Benzene (µg/m³)	Benzo (a) pyrene (ng/m³)	Arsenic (As) (ng/m³)	Nickel (Ni) (ng/m³)
1	S.J. Hospital	BDL (<0.001)	0.12	1.5	<1	<1	BDL (DL-)	BDL (DL-)
2	Gyasi Nagla	BDL (<0.001)	BDL	1.9	<1	<1	BDL (DL-)	BDL (DL-)
3	Dhana Teja	BDL (<0.001)	0.11	2.0	<1	<1	BDL (DL-)	BDL (DL-)
4	Chharhgaon	BDL (<0.001)	BDL (<0.001)	1.9	<1	<1	BDL (DL-)	BDL (DL-)
5	Barari	BDL (<0.001)	BDL (<0.001)	2.7	<1	<1	BDL (DL-)	BDL (DL-)
6	Dhana Shamsabad	BDL (<0.001)	BDL (<0.001)	1.6	<1	<1	BDL (DL-)	BDL (DL-)
7	Bhahai	BDL (<0.001)	BDL (<0.001)	1.7	<1	<1	BDL (DL-)	BDL (DL-)
8	Farah	BDL (<0.001)	BDL (<0.001)	1.5	<1	<1	BDL (DL-)	BDL (DL-)
9	NAAQ Standard for Industrial, Residential, Rural and Other area	-	-	400	-	-	-	-

Note: BDL (Below detectable limit), DL (Detectable limit)

4.9.3. Observation of the Results

PM_{10}- Average, minimum and maximum reported concentrations of PM_{10} are presented in Table 4.13. The maximum value was observed at the range of 93.0 µg/m³ to 103.0 µg/m³ due to proximity to the existing industries and refinery which is already under operation. At all ambient air quality locations, the PM_{10} levels recorded were within the prescribed NAAQ standards of 100 µg/m³ for 24 hours.

Table 4-13 Measured Ambient PM_{10} Concentration during Study Period *(25-11-2016 to 23-02-2017)*

S. No	Location	PM_{10} Concentration µg/m³		
		Minimum, µg/m³	Maximum, µg/m³	Average, µg/m³
1	S.J. Hospital	65.0	96.0	85.2
2	Gyasi Nagla	80.0	98.0	89.7
3	Dhana Teja	85.0	103.0	92.0
4	Chharhgaon	65.0	93.0	79.5
5	Barari	71.0	102.4	88.7

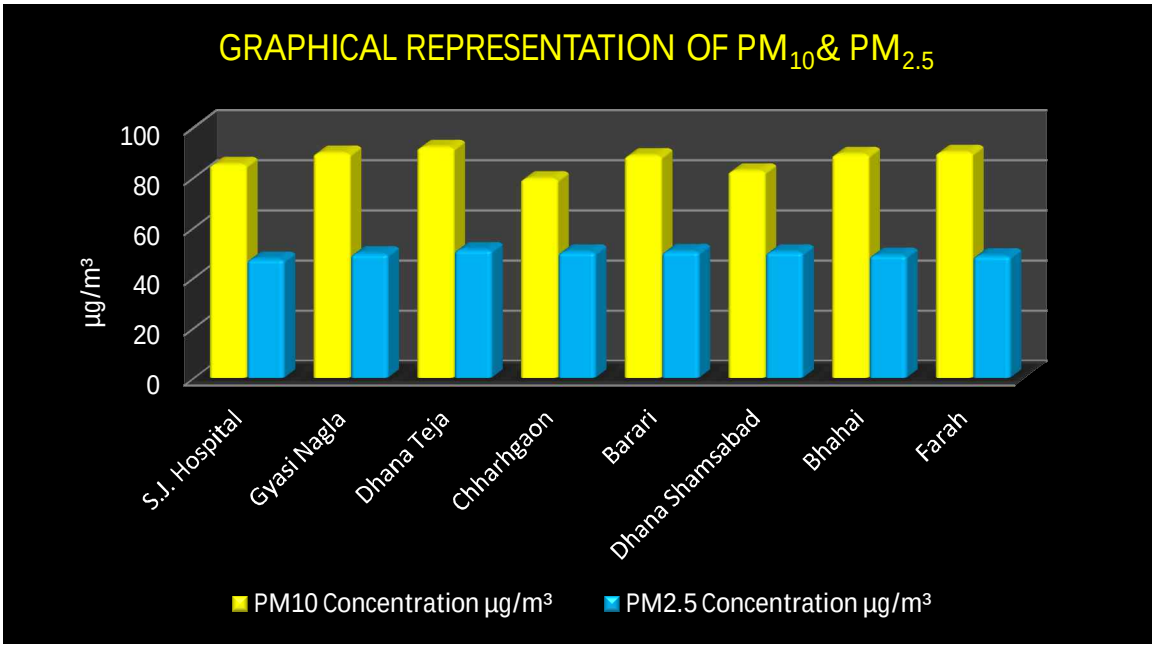
S. No	Location	PM_{10} Concentration µg/m³		
		Minimum, µg/m³	Maximum, µg/m³	Average, µg/m³
6	Dhana Shamsabad	65.0	97.0	82.6
7	Bhahai	82.0	103.0	89.2
8	Farah	79.0	95.0	90.0

$PM_{2.5}$- Average, minimum and maximum reported concentrations of $PM_{2.5}$ are presented in Table 4.14. The maximum value was observed at the range of 53.1 µg/m³ to 59.2 µg/m³. At all ambient air quality locations the $PM_{2.5}$ levels recorded are within the prescribed NAAQ standards of 60 µg/m³ for 24 hours.

Table 4-14 Measured Ambient $PM_{2.5}$ Concentration during Study Period *(25-11-2016 to 23-02-2017)*

S. No	Location	$PM_{2.5}$ Concentration µg/m³		
		Minimum, µg/m³	Maximum, µg/m³	Average, µg/m³
1	S.J. Hospital	40.9	53.1	47.4
2	Gyasi Nagla	44.1	56.3	49.6
3	Dhana Teja	48.2	55.1	51.2
4	Chharhgaon	41.3	55.2	50.3
5	Barari	42.1	59.2	50.5
6	Dhana Shamsabad	41.3	55.7	50.3
7	Bhahai	42.1	53.7	49.0
8	Farah	42.3	59.2	48.8

Figure 4-20 Graphical Representation of PM10 & PM2.5



SO_2- Average, minimum and maximum reported concentrations of SO_2 are presented in Table 4.15. The maximum value was observed at range of 9.9 µg/m³ to 17.9 µg/m³. At all ambient air quality locations, the SO_2 levels recorded are within the prescribed NAAQ standards of 80 µg/m³ for 24 hours.

Table 4-15 Measured Ambient SO_2 Concentrations during Study Period *(25-11-2016 to 23-02-2017)*

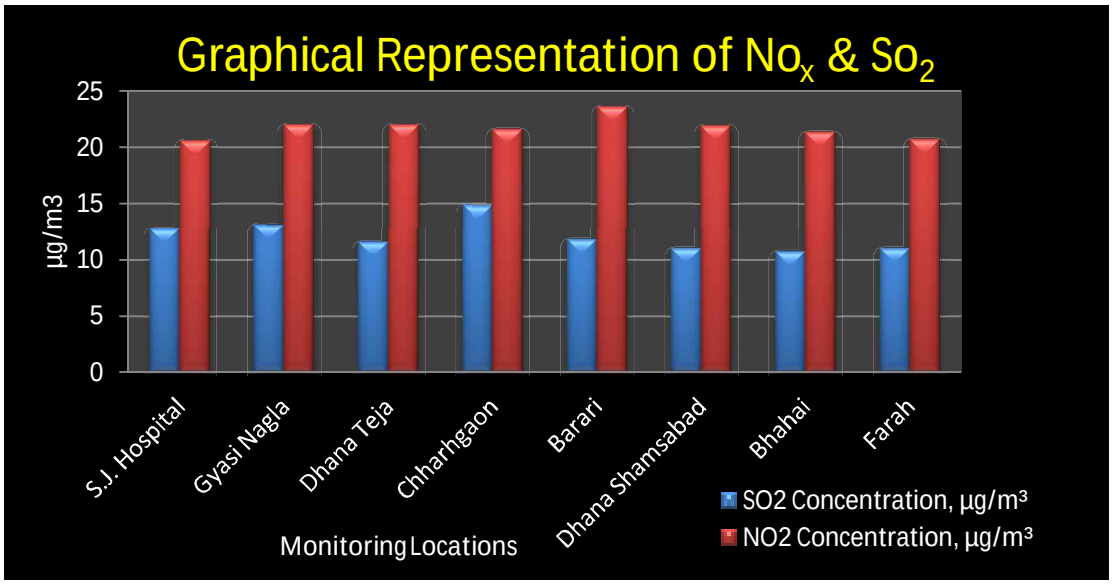
S. No	Location	SO_2 Concentration, µg/m³		
		Minimum, µg/m³	Maximum, µg/m³	Average, µg/m³
1	S.J. Hospital	9.9	17.9	12.8
2	Gyasi Nagla	10.5	18	13.1
3	Dhana Teja	9	14.6	11.6
4	Chharhgaon	9	9.9	14.9
5	Barari	9.8	16	11.8
6	Dhana Shamsabad	9	14.2	11.0
7	Bhahai	7.9	14.2	10.7
8	Farah	8.6	12.7	11.0

NO_x- Average, minimum and maximum reported concentrations of NO_X are presented in Table 4.16. The maximum value was observed at range of 23.1µg/m³ to 28.3µg/m³. At all ambient air quality locations, the NO_X levels recorded are within the prescribed NAAQ standards of 80µg/m³ for 24 hours.

Table 4-16 Measured Ambient NO_x Concentrations during Study Period *(25-11-2016 to 23-02-2017)*

S. No	Location	NO_x Concentration, µg/m³		
		Minimum, µg/m³	Maximum, µg/m³	Average, µg/m³
1	S.J. Hospital	18.3	24.5	20.6
2	Gyasi Nagla	18.3	24.5	22.0
3	Dhana Teja	18.8	27.4	22.0
4	Chharhgaon	18.3	24.3	21.6
5	Barari	20.4	28.3	23.6
6	Dhana Shamsabad	18.3	25.0	21.9
7	Bhahai	18.9	24.2	21.3
8	Farah	18.0	23.1	20.7

Figure 4-21 Graphical Representation of NO_X & SO_2



Other Parameters- Other parameters like CO, O_3 and Ammonia are within the NAAQ standard. PB, Arsenic, Nickel Benzene, Benzo (a) pyrene (particulate phase) are below detectable limits.

4.10. Noise Environment

To evaluate the noise level in the study area, noise levels were recorded at the project site and other seven locations in the study area. The measurements were carried out using Type 1 noise level integrated sound level meter. Monitoring was done at each location during the study period for 24 hrs on hourly basis to obtain hourly equivalent sound pressure level. A digital noise level meter was used to record the noise levels. From these values, day time and night time and 24-hrs L_{eq} values were calculated. Day time is considered from 0600 hrs to 2200 hrs and night from 2200 hrs to 0600 hrs.

Noise monitoring locations is given in Table 4.17 and noise level equivalent values are presented in Table 4.18. The measured noise levels have been compared with the standard specified in Schedule III, Rule 3 of Environmental Protection Rules. Noise monitoring test report is attached as Annexure-16.

Figure 4-22 Noise Monitoring Locations in the Study Area

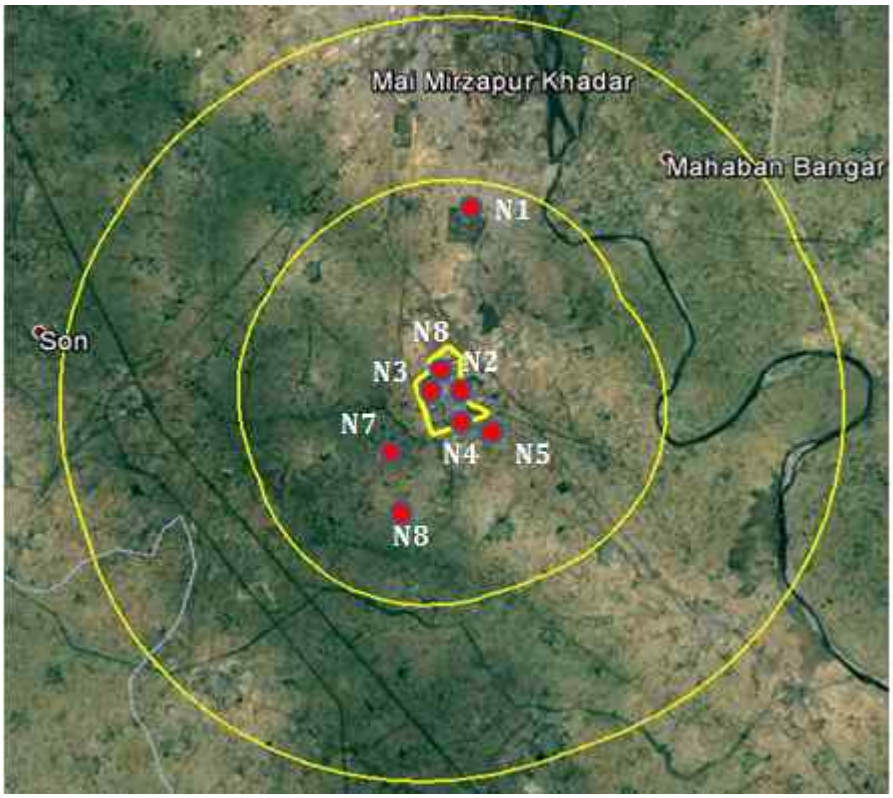


Table 4-17 Noise Sampling Locations

S. No	Location Name	Location Code	Category of Area/ Zone	Direction	Distance (km) from project site
1	S.J Hospital	N1	Residential & mixed Zone	North	4.5
2	Refinery Main Gate	N2	Industrial Area	North east	0.5
3	Refinery Project Site	N3	Industrial Area	-	-
4	Refinery Plant Boundary away from Gate No-9	N4	Industrial Area	South	0.5
5	Dhana Teja Village	N5	Residential Area	South east	0.7
6	Green Building within Plant Area	N6	Industrial Area	South	0.2
7	Chhargaon village	N7	Residential Area	South West	2.0
8	Dhana Shamsabad village	N8	Residential Area	South	2.5

Table 4-18 Noise Level Equivalent Values during Study Period *(25-11-2016 to 23-02-2017)*

S.No	Location	Day Time dB (A) Leq*	Night Time dB (A) Leq*	CPCB Limits in dB(A) Leq	
				Day time*	Night time*
1	S.J Hospital	44.8	39.1	55	45

S.No	Location	Day Time dB (A) Leq*	Night Time dB (A) Leq*	CPCB Limits in dB(A) Leq	
				Day time*	Night time*
2	Refinery Main Gate	58.7	52.4	75	70
3	Refinery Project Site	58.7	52.4	75	70
4	Refinery Plant Boundary away from Gate No-9	56.1	53.9	75	70
5	Dhana Teja Village	49.1	42.2	55	45
6	Green Building within Plant Area	53.6	50.5	75	70
7	Chhargaon village	48.3	41.6	55	45
8	Dhana Shamsabad village	49.8	42.1	55	45

*Note: *1- Day time shall mean from 6.00 a.m. to 10.00 p.m. *2- Night time shall mean from10.00 p.m. to 6.00 a.m.*

Observations - Average day time and night time noise levels at residential areas in the study area was found to be varying from 44.8 dB (A) to 58.7 dB (A) and 39.1 dB(A) to 53.9 dB(A) respectively. Noise level at industrial area i.e. IOCL refinery plant, it was found to be 58.7 dB(A) during day time and 52.4 dB (A) during night time which is within the CPCB limits for industrial areas.

4.11. Water Environment

Both surface and ground water resources and water quality have been studied within the 10 km radius of the Project site under this EIA study. The source of water for the refinery is River Yamuna.

4.11.1. Surface Water Quality

The River Yamuna (Koyala) and artificial reservoir Keetham are the major surface water resources of the area. River Yamuna is located at 6 km on the Eastern direction of the Mathura Refinery.

Water quality parameters of surface water resources within the study area have been considered for assessing the water environment. To assess the water quality of the study area a surface water sampling location was selected in two locations. The water sample was collected in the River Yamuna near to the Upstream and downstream of the River which is the major source of water for the project. The location detail of the sampling is given below in Table 4.19.

Table 4-19 Surface Water sampling

Location	Location Code
Yamuna River (Koyala), Upstream	SW 1
Yamuna River (Koyala), Downstream	SW 2

The observation of the surface water sample is given below and surface water quality analysis report is enclosed in *Annexure-17.*

4.11.2. Observation

The results show that pH ranges slightly alkaline along the upstream of the Yamuna River, this may be due to the contamination of the river water in the upstream due activities of bathing are clothes washing, this activity contributes inorganic, organic and biological contaminants in the river water besides detergents. The ranges for desirable limit of pH of water prescribed for drinking purpose by IS:10500, 2012 is 6.5 to 8.5. The TDS in the upstream and downstream of the river is 724 mg/l and 690 mg/l. The Heavy metals concentration is well within the drinking water quality standards. Bacteriological studies reveal that Coliform bacteria is absent in the samples.

4.11.3. Yamuna River Quality of the Study Area – (Published Data)

As per the "*Water quality status report of Yamuna River by Central Pollution Control Board (Ministry Of Environment & Forests), November 2006"* states that Most of the rivers including River Yamuna are spiritually regarded as mother. People from all over the country visit various stretches of this river especially at Yamunotri, Paonta Sahib, Mathura-Vrindavan and Bateshwar to take holy dip in river water to purge away their sins. Thus, the river portrays Indian culture and traditions. Deteriorate water quality and quantity of Yamuna River hurts the sentiments of Indian masses besides having several adverse impacts on life process in the river. River Yamuna receives significantly high amount of organic matter, which is generally, originates from domestic sources. Organic, inorganic and toxic pollutants generated from agricultural and industrial sources are accumulated near the source during dry seasons and get mixed with river water posing threat to aquatic life during monsoon or percolated to ground water and making water unfit for human consumption.

To cover the entire Yamuna River stretch five additional locations in 738 km long stretch between Yamunotri to Hathnikund and Auraiya to Allahabad and on Tons River at one location each are also being monitored regularly.

Mathura Upstream- This location of river is being monitored to assess the water quality of Yamuna before it enters Vrindavan – Mathura and Mathura Downstream - The site depicts the impact of wastewater discharges from Mathura-Vrindavan city.

At Mathura there is not much variation in BOD level at upstream and downstream locations. At upstream and downstream BOD level was in the range of 3 – 25 mg/l and 3 - 21 mg/l respectively with similar annual average.

A River about to Die: Yamuna, Journal of Water Resource and Protection Vol.2 No.5(2010), Article ID:1806,12 pagesDOI:10.4236/jwarp.2010.25056 by Anil Kumar Misra, Department of Civil Engineering, Institute of Technology and Management, Gurgaon, India states that High demand of BOD indicates that the level of dissolved oxygen is falling, and river's marine life and biodiversity is in danger. COD beyond the permissible limit is the indicator of the organic and inorganic pollutants in the water body.

4.11.4. Ground Water Resources

As per the CGWB, groundwater flows towards East and South-East in the Mathura District. This is contrary to the surface water flow direction, which flow towards North and North-East as the groundwater potential lines intersect them. The seepage from Agra canal and Farah distributor significantly contributes to the lateral inflow to the aquifer along the western boundary.

4.11.5. Ground Water Quality

Selected water quality parameters of ground water resources within the study area have been considered for assessing the water environment. To assess the water quality of the study area, eight (8) ground water sampling locations were selected. These samples were collected as grab samples and were analysed for various parameters. Forty four (44) water quality parameters are analysed. The water sampling locations are listed below in Table 4.20 and the locations are marked in 10 km map which is given below in Figure 4.23.

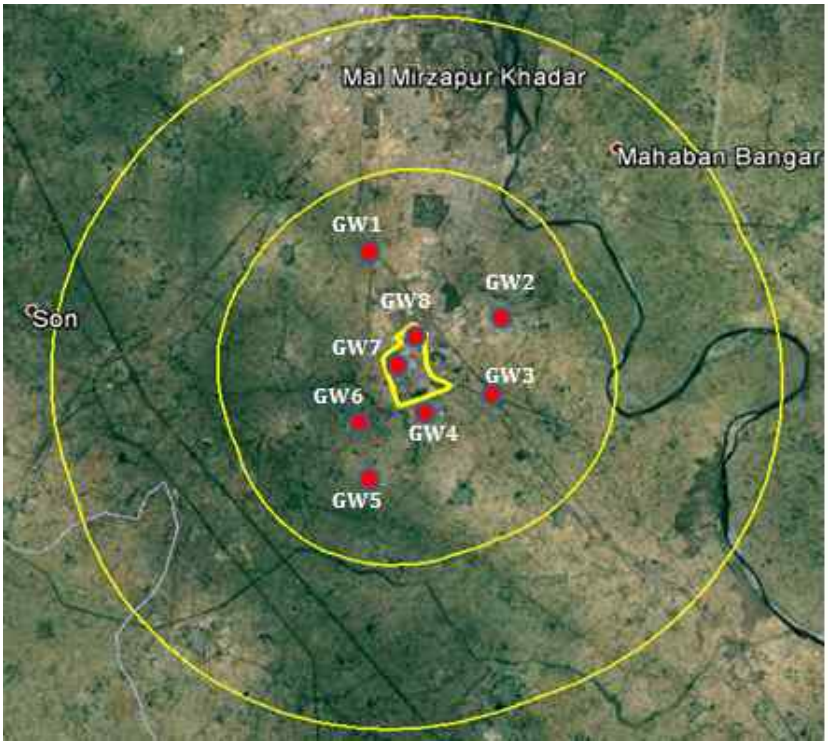
Table 4-20: Details of Water Sampling Locations

Location	Location Code	Direction	Distance with respect to the site
Baad	GW1	N	3.0
Nagla Gyasi	GW2	E	2.8

Location	Location Code	Direction	Distance with respect to the site
Barari	GW3	SE	1.9
Dhana Teja	GW4	S	0.4
Dhana Shamsabad	GW5	S	2.5
Chharhgaon	GW6	SW	2
Bore Well, located near Gate No.9	GW7	S	0.5
Hand pump, located in tank forming area	GW8	N	0.5

Observation- The analysis results of ground water samples indicate that the average pH ranges in between 7.1 to 7.87, TDS ranges from 1028 mg/l to 1992 mg/l, TDS in the Project site is 1643 mg/l. Total hardness is in the range of 92 mg/l to 804 mg/l which is also higher than the desirable limit. The heavy metal concentration is Below Detectable Limit in all sampled locations and well within the standards for drinking water as per IS: 10500 –1991 "Specification for drinking Water" for ground water. Fluorides concentrations are in the ranges of 0.22 mg/l to 0.28 mg/l which are found within the drinking water standards. The ground water analysis results are compared with the standards for drinking water as per IS: 10500 –1991 "Specification for drinking Water" for ground water. The analysis report is enclosed as *Annexure-18*.

Figure 4-23 Location of Ground Water Sampling in the Study Area(10 km radius)



4.11.6. Treated Wastewater Quality

The effluent treatment plant has been modernized in 2008 to meet new environment standard (EP, 2008). The treated effluent is recycled as make-up to cooling tower and DM plant feed. The treated water mixed with reverse osmosis plant rejects and cooling tower blow-down is being used for firewater, horticulture and construction activities. The balance unutilized excess treated effluent is discharged to Yamuna River (Koyala point) - about 10 Km from refinery through a dedicated channel. Since there is no increase in the water requirement, the effluent generation after the post project scenario is minimal.

Treated Wastewater has been analyzed for physico-chemical properties. The results of treated wastewater are compared with General Standards for Discharge of Environmental Pollutants Part-A: Effluents under Schedule – VI, GSR-422 (E) of The Environment (Protection) Rules, 1986. The reports are attached as *Annexure-19.*

Table 4-21 Treated Wastewater Characteristics

S.No.	Parameter	Unit	Results	Petroleum Refineries - Specific Treated Wastewater Discharge Standards
1.	pH	--	6.65	6.0- 8.5
2.	Oil & Grease	mg/l	<5.0	5
3.	Total Suspended Solid(as TSS)	mg/l	16.0	20
4.	Chemical Oxygen Demand (COD)	mg/l	24.0	125
5.	Biochemical Oxygen Demand (BOD) 3days at 27° C	mg/l	6.0	15

The analysis results indicate that the pH was found to be 6.65. The TDS values are observed to be 16 mg/l, which have been observed to be well within the specific discharge standard. The temperature of the treated wastewater is almost the same as ambient temperature. BOD and COD values are within the specific discharge standard.

4.12. Ecological Environment

Living things are organized in to natural communities with mutual dependencies among their members, and they show various responses and sensitivities to the outside influences. However, the process of rapid development and industrialization has marked some prominent questions about survival of the flora and fauna. Fortunately, global awareness during past few years has been augmenting and worldwide programs

for wild life conservation have been formulated. The worldwide-accepted concept of 'Sustainable development' has given a vision of eco-friendly project execution.

4.12.1. Necessity of the Ecology Management Plan

Monitoring the influence of anthropogenic activities on flagship species is an important part of conserving biodiversity, because the information gained is crucial for the development and adaptation of conservation management plans. Ecological monitoring provides feedback about the actual environmental impacts of a project. Monitoring results help judge the success of mitigation measures in protecting the environment. They are also used to ensure compliance with environmental standards, and to facilitate any needed project design or operational changes.

Regulatory bodies worldwide are increasingly recognizing the fact that human activities are causing environmental and ecological damage. To effectively deal with this environmental crisis, it is important to understand its dimensions and dynamics. What specifically are the damages, how are they changing over time, and the best means of prevention or mitigation. To develop precise ecology management plan, longer-term programs of monitoring and research must be designed and implemented. Such programs are capable of detecting environmental and ecological change over large areas, and of developing an understanding of the causes and consequences of those changes.

4.12.2. Objectives of Ecological Monitoring

a) To evaluate the prevailing ecological status of the habitats adjacent to the existing Refinery
b) To evaluate positive impacts of greenbelt developed by IOCL
c) To assess the impact of proposed expansion on flora, avifauna and mammals
d) To recommend suitable environment management plan to minimize any adverse impact on adjacent area due to the proposed developments.

4.12.3. Methodology

4.12.3.1. Flora survey

All accessible sites will be identified within the study area of 10km such that the ecosystems and land-use types are represented accordingly. The prediction of impacts on flora and fauna depends on understanding of the proposed project activities, its

magnitude/extent, scale and ecological conditions in the surrounding area. Collection of rapid baseline information on flora and fauna is therefore a prerequisite for assessment of impacts of the development activities. All the accessible and identified sites will be divided into four zones with respect to their distance from the project site: Zone I - sites which fall in the project site i.e. core zone, Zone II mention the boundary of core zone to 2.5KM, Zone III indicate 2.5 to 5KM, Zone IV - sites which lie on the outermost zone extending from 5KM to 10KM. All the four Zones of lands would be mapped for their biological diversity.

Diversity assessment for different plant species and the analysis of Rare –Endemic – Endangered and Threatened flora was carried out. At each site, a study of floral diversity was carried out in the following manner. A quadrant of approximately 20 m x 20 m was marked. The species of trees, shrubs and large climbers, as well as the number of individuals of each species, falling within this area were noted. A quadrant of approximately 5 m x 5 m was marked within this larger quadrate. The species of herbs, both grasses and forbs, and the number of individuals of each species, falling within this area were noted. Smaller quadrate of 1m x 1 m for the more prolifically-growing larger herbs, and 10 cm x 10 cm, for prolifically-growing minute herbs, were employed when required.

Equipment / Instruments Used

- Quadrates/Measuring Tape
- Measuring tapes
- GPS
- Camera
- Binocular and
- Plankton net

4.12.3.2. Faunal Assessment

A detailed study in has been carried out to cross check the list taken from secondary source and local villagers. In case of vertebrate species, no sampling could be done. Depending on as and when sighted, the species will be recorded if found within the delimited project and buffer areas, the animal species are listed on secondary data and circumstances evidence besides direct observations. These techniques are accepted in

EIA studies as per the EIA Notification of 2006. Observations made on direct and indirect evidences for mammalian, avifauna and reptilian fauna within the study area. Analyses of Scheduled species identify Habitat/microhabitat diversity in the project site and surrounding areas within 10Km range from the site. Flora and fauna studies were carried out during 31st January – 3rd February 2017 to assess the list of terrestrial plant and animal species that occur in the core zone and the buffer zone up to 10 km distance from the core zone boundary. The biodiversity of the survey area was then evaluated in terms of Species richness of the woody flora and the avifauna, percentage frequency, abundance and density of each floral species, and Evenness.

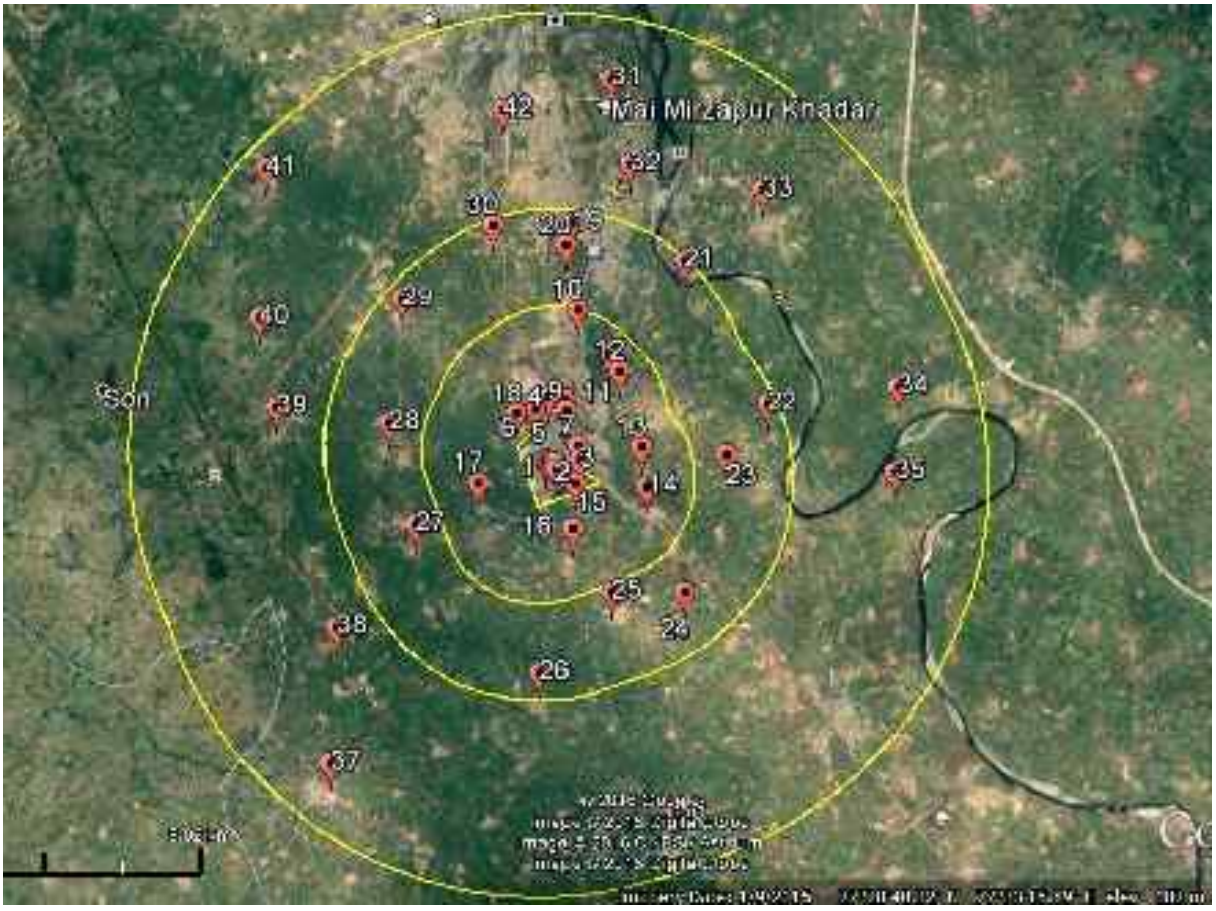
The ecological survey location details were showed in below Table 4.22 and the photographs showing the Terrestrial ecological survey is given in Figure 4.24.

Table 4-22 **Terrestrial Ecology Sampling Locations**

Locations	Latitude	Longitude
Zone – I : Core zone project area		
1	27°22'15.18"N	77°41'15.22"E
2	27°22'19.78"N	77°41'13.88"E
3	27°22'22.97"N	77°41'35.96"E
4	27°23'13.51"N	77°41'21.47"E
5	27°23'15.26"N	77°41'8.37"E
6	27°23'5.02"N	77°40'55.60"E
7	27°22'34.10"N	77°41'34.71"E
8	27°22'22.29"N	77°41'5.19"E
9	27°23'3.49"N	77°41'24.31"E
Zone – II : Project area boundary to 2.5km radius		
10	27°24'27.41"N	77°41'34.68"E
11	27°23'49.64"N	77°42'3.64"E
12	27°23'36.63"N	77°42'14.22"E
13	27°22'32.71"N	77°42'34.80"E
14	27°22'0.48"N	77°42'39.20"E
15	27°22'3.49"N	77°41'32.31"E
16	27°21'25.56"N	77°41'29.55"E
17	27°22'4.19"N	77°40'1.94"E
18	27°23'1.66"N	77°40'37.52"E
Zone – III : Boundary of 2.5km to 5km radius		
19	27°25'39.08"N	77°41'29.73"E
20	27°25'20.90"N	77°41'24.79"E
21	27°25'6.89"N	77°43'15.16"E
22	27°23'8.31"N	77°44'32.08"E
23	27°22'26.17"N	77°43'53.32"E
24	27°20'32.63"N	77°43'13.80"E
25	27°20'33.15"N	77°42'6.10"E

Locations	Latitude	Longitude
26	27°19'26.47"N	77°40'57.86"E
27	27°21'29.59"N	77°39'2.43"E
28	27°22'54.07"N	77°38'39.33"E
29	27°24'37.10"N	77°38'51.47"E
30	27°25'37.62"N	77°40'16.48"E
Zone – IV : Boundary of 5.0km to 10km radius		
31	27°27'38.07"N	77°42'8.40"E
32	27°26'27.31"N	77°42'25.51"E
33	27°26'5.79"N	77°44'28.69"E
34	27°23'21.91"N	77°46'34.20"E
35	27°22'11.16"N	77°46'30.70"E
36	27°17'30.42"N	77°43'4.37"E
37	27°18'12.64"N	77°37'41.90"E
38	27°20'4.82"N	77°37'48.69"E
39	27°23'8.01"N	77°36'53.73"E
40	27°24'21.85"N	77°36'37.82"E
41	27°26'25.52"N	77°36'44.64"E
42	27°27'13.59"N	77°40'25.82"E

Figure 4-24 **Locations of Terrestrial ecological survey**



Core Zone study: Within the core area, 9 sampling points were selected to quantify the data. The core zone boundary is up to 5 sq km and the basically there is no forest land in the proposed project activity area.

Buffer zone study: From 5 km to 10 Km radius is treated as buffer zone and 33 samples of 20m^2 each were chosen by taking the following parameters into consideration.

- Grasses
- Riverine Vegetation
- Reserve Forests
- Social Forestry
- Green Belt
- Aquatic Vegetation
- Villages
- Cultivation

4.12.3.3. Quantitative Analysis of the Vegetation

Plot-based random quadrate sampling method was adopted to generate the Phytosociological data *viz.*, density, frequency, abundance and important value index (IVI). Quadrates of 20 m x 20 m size were laid out for the enumeration of the tree species, quadrates of 5 m x 5 m for shrubs and saplings and quadrates of 1 m x 1 m for herbs and seedlings.

Diameter at breast height (DBH) of 130 cm was consistently used during the present study. In no case, the thicker part near branching position was considered. Instead diameter of the tree having a branch at about 130 cm was measured either below 30 cm from the branch or in case of all the stems above 30 cm from the branch and averaged.

All individuals above 10 cm of girth at breast height (GBH) were considered as trees and all individuals below 10 cm of GBH or 2 m of height as shrubs and saplings. In each unit, presence or absence of the species, number of individuals of each species, GBH (only for tree species) to estimate basal area of the tree species were recorded.

Other ecological parameters *viz.*, abundance, density, frequency, IVI, Shannon-Wiener diversity index, Simpson's dominance index, Abundance/Frequency (A/F) ratio for

distribution pattern of species and Similarity Index were derived from the above basic data.

Frequency, density, abundance and basal area were calculated following Misra (1968).

$$\text{Frequency:} \quad \frac{\text{Number of sampling units in which a species occurs}}{\text{Total number of sampling units studied}} \text{ X } 100$$

The frequency of individual species is the number of times the species occurs in the sampling quadrant.

$$\text{Density:} \quad \frac{\text{Total number of individuals in all sampling units}}{\text{Total number of sampling units studied}}$$

Density is the measure of dense in the distribution of an individual species within a given area.

$$\text{Abundance:} \quad \frac{\text{Total number of individuals in all sampling units}}{\text{Total number of sampling units of occurrence}}$$

$$\textbf{Dominance} = \frac{\text{Total basal area or crown}}{\text{Total area sampled}} \text{ X } 100$$

It reflects the species basal area covered by a species within the sampling area.

Relative Density and Dominance

The relative density and dominance values of different species found in the study are shows that the dominant plants of various sites have a high percentage value of density and dominance. These values are incorporated in calculating the Importance value Index.

$$\text{Relative density:} \quad \frac{\text{Number of individuals of a species}}{\text{Total number of individuals of all species}} \text{ X } 100$$

$$\text{Relative frequency:} \quad \frac{\text{Number of occurrences of a species}}{} \text{ X } 100$$

$$\text{Relative basal area: } \frac{\text{Total basal area of individual species}}{\text{Total basal areas of all species}} \text{ X } 100$$

Total number of occurrences of all species

Importance Value Index (IVI)

Important Value Index was estimated from the formula developed by Cottam and Curtis (1956). **IVI:** RD + RF +RBA

IVI for trees (300) was derived from relative density (RD), relative frequency (RF) and relative basal area (RBA) whereas the same was calculated for shrubs (200) and herbs (200) from only relative frequency and relative density. The Importance Value Index (IVI) is an expression used to summarize the plant data; it is desirable to use as many values as possible. The Importance value allows quantitative comparison of each species in a stand with the other species in the stand, or allows comparison of the species in one stand with species in other stands.

4.12.4. Aquatic Environment

The phytoplankton and zooplankton reflect the productivity of a water column at the primary and secondary levels, respectively.

4.12.5. Plankton

The plankton samples were collected from Yamuna River with a Hand net (having 0.10 m^2 mouth area and 300 µm mesh size). All the samples were preserved in 5% neutralized formaldehyde solution. Different plankton taxa were sorted, identified and enumerated under stereoscopic zoom binocular microscope. The number were calculated for the whole samples and given for 100m^3 of water.

Figure 4-25 **Plankton Sampling at River Yamuna**

4.12.6. Observations

The published literature and previous EIA study reports are used for finalize the list of core and buffer zone species. Secondary data compared with the existing sighted species in the study areas. The flora and fauna lists also cross checked with the local communities. An effort has been made to identify the impacts of the proposed expansion of refineries at different stages. Floral and faunal resources used by local communities such as timber, medicinal and fishing etc are also collected. The mitigation measures were suggested and conservation of Scheduled species (if any) will be given.

4.12.7. Reserve Forests

In the buffer zone of the study area at Baad and Kurkunda villages approximately 36.7 Ha and 9.08 Ha were categorized as Reserve Forests. These green patches of land were dominated by exotic alien species the *Prosopis juliflora and* stunted growth of *Casuarina* and shrubs like *Cassia auriculata* were observed. This forest area inhabited by snakes, Wild pig and Monkey was confirmed by local communities. Natural forests are absent in the study area. There is another reserved forest - Farah-Salempur Reserved forests, which is about 17 km from the refinery and covers an area of 87.04Ha.

Figure 4-26 **Baad Reserve Forest in zone II Buffer**


4.12.8. Social Forestry

Having been devoid of any vegetation for long the soil in the area has very low fertility. In such areas species of *Acacia* and *Prosopis* have been planted predominantly. Besides these *Azadirachta indica, Pongamia pinnata, Holeopetela integraifolia, Dalbergia sisoo. Delonix regia, Albezia labeckk and Polyalthia longifolia* have also been planted. The plantations have been done by the sides of canals and roads. Majority of the roadside plantations include trees with canopy such as mango, neem, arjun and Eucalyptus.

Figure 4-27 Trees nearby village and along the road side


4.12.9. Grasses

Grasses are normally found in sandy soils and the Yamuna river bank. *Saccharum spontaneum* is found in low lying area. *Typha elephatina* is found in moist and water shed areas. Other grasses which are observed are *Cynodon dacylon*, *Sporoboils marginatus*, *Dactyloctenium acgyptium* and *Cyperus* Sp. Grasses were observed to grow in vast stretches on uncultivated lands, roadside and along the sides of canals.

4.12.10. Riverine Forests

This is found along the banks of river Yamuna consisting predominantly of Acacia Leucophloea, Salvadora aleoids, Crythrina subrosa, Samanya siamia, Prosopis cineraria and Acacia arabica.

Figure 4-28 River Yamuna and along the bank

4.12.11. Aquatic Vegetation

In ponds at Eco-park of Mathura Refinery patches of Spirodela Sp. and *Lemna Sp., Hydrilla Sp., Ceratophyllum sp.* and *Vallisnaria Sp.* were observed. Aquatic and semi aquatic plants macrophytes were found in the ponds, small streams, wetlands and wheat fields and drains. Mainly *Typha, Ipomia aquatica, Eichhornia crassipes* and *Pistia stratiotes* were most abundant in fresh water wetlands.

Figure 4-29 Eichhornia crassipes infestation in **a** pond and agriculture field at Chadgaon

Wetland: No wetland notified under "The Ramsar Convention – 1971" or listed under "the National wetland Conservation Programme – 2009" is reported within 10 km from project boundary.

Wetland near the bank of River Yamuna inhabited by large number of spot billed duck and Black winged stilt their congregations and foraging were also observed during site visit.

Figure 4-30 Spot billed duck and Black winged stilt along the Yamuna River bank

Table 4-23 **Phytoplankton Species Recorded in River Yamuna**

S.No.	Family	Algal Species
1	Cyanophyceae	*Osillatoria* sp. *Merismopedia* sp.
2	Bacillariophyceae	*Navicula* sp. *Nitzschia* sp. *Cymbella* sp. *Cyclotella* sp,
3	Chlorophyceae	*Ankistrodesnus* sp., *Scenedesmus* sp., *Cosmarium* sp. *Chlorococcum* sp.*Chlamydomonas* sp. *Closterium* sp.

Table 4-24 **List of Zooplankton Species Recorded in River Yamuna**

S.No.	Order	Species
1.	Protozoa	*Acanthocystis* sp.
2.	Rotifera	*Brachionus* sp. *Keratella* sp.
3.	Cladocera	*Daphnia* sp. *Chydorus* sp. *Moina* sp.
4.	Copepoda	*Cyclops* sp. *Nauplius larva*

4.12.12. Agriculture Land

The lands near settlements were mainly agricultural fields. Potato and Mustard cultivations were observed along with major crops fields of Wheat. The vegetation around homes includes mainly fruit or vegetable-yielding species such as *Annona squamosa*, *Mangifera indica*, *Manilkara zapota*, *Moringa oleifera* and *Psidium guyava* or trees and shrubs bearing showy flowers such as *Delonix regia*, *Nerium oleander* and *Calotropis gigantea*.

Figure 4-31 Wheat, Potato and Mustard field in the study area

4.12.13. Green Belt and Horticulture Program

Massive afforestation activities have been undertaken by Mathura Refinery. Besides serving as a population sink, this green cover also enhances the aesthetic look. The refinery has so far planted about 29,749 trees/shrubs in the refinery premises and more than one lac trees/shrubs in the surrounding area and township. Mathura Refinery, as a responsible corporate entity, is committed for upkeep of the environment beyond its boundaries as well; the refinery has taken extra –ordinary initiatives to provide green cover to the archaeological heritage sites especially the Taj Mahal by planting 80,000 trees in Taj Reserve Forest and 35,000 trees in Renukata Reserve Forest. Plantation has also been conducted in the Mathura region, under this program around 21,959 numbers of selected plant species have been planted in Mathura and Govardhan region. Around 9000 saplings have also been planted along NH-2 from Mathura (Krishna Nagar) to Farah in 2004 through Social Forestry Dept., Mathura.

An ecological park has been developed within the refinery premises. As per the information provided, tree plantation in the ecological park was conducted under the guidance of Mr. D.N. Rao, an eminent Professor of the Banaras Hindu University.

Plant species have been selected based on their survival rate, local climatic conditions and edaphic characters. A list of these species under Horticulture and tree plantation

program is presented in Table 4.25. The greenbelt in Mathura Refinery premises as well as in the township were developed before the 'Guidelines for developing Greenbelts' provided by the CPCB. However, on verification, it has been found that most of the species existing in the greenbelts match with CPCB guidelines as indicated in Table 4.26. Besides these, there are few exotic ornamental species and native species are planted which are necessary to form a complete ecosystem.

Table 4-25 Plantation details under Horticulture and Tree Plantation Program

Location	Township	Refinery	Villages	Taj Reserve Forest	Runakta Reserve Forest	Mathura Region	Total
Till 1996	64965	24193	28446	15000	35000	-	167604
1997	4497	3556	-	-	-	-	8053
1998	1000	-	5400	50000	-	-	56400
1999	1500	1000	-	-	-	-	2500
2000	1476	-	-	-	-	-	1476
2001	-	100	-	15000	-	-	15100
2002	-	350	-	-	-	9000	9350
2003	-	-	-	-	-	1000	1000
2004	-	400	-	-	-	9000	9400
2005	-	-	-	-	-	3000	3000
2006	-	-	-	-	-	1859	1859
2007	-	-	-	-	-	7000	7000
2008	1000	-	-	-	-	-	1000
2009	1000	-	-	-	-	-	1000
2010	200	150	250	-	-	100	700
2011	100	-	-	-	-	-	100
2012	1628	-	-	-	-	-	1628
2013	25	5	-	-	-	2500	2530
2014	1525	-	100	-	-	1000	2625
2015	1350	-	-	-	-	-	1350
2016 (till date)	514	-	-	-	-	-	514
Total	80780	29754	34196	80000	35000	34459	294189

- Ecological Park Area – 4.45 Acre
- Taj Reserve Forest Area (Tree Plantation by Mathura Refinery) – 61.25 Hectare
- Runakta Reserve Forest Area (Tree Plantation by Mathura Refinery) – 35 Hectare

Figure 4-32 Ecological Park inside the Refinery


Green belt area in the Township






Table 4-26 List of Plant Species under Horticulture and Tree Plantation Activities

S.No.	Botanical Name	Common Name	S. No. As per CPCB Guidelines
1	*Acacia auriculiformis*	Australian Wattle, Kikar	A2
2	*Acacia nilotica*	Babool	A10
3	*Aegle marmelos*	Bel	A22
4	*Albizia lebbeck*	Siris	A29
5	*Albizia moluccana*	Vilatibaral	A30
6	*Alstonia scholaris*	Devil Tree	A36
7	*Anthocephalus kadamba*	Kadamba	A40
8	*Artocarpus*	Kathal	A42
9	*Azadirachta indica*	Neem	A44
10	*Bauhinia acuminata*	Kanchan	B6
11	*Bauhinia variegata*	Kachnaar	B10
12	*Bougainvillea spectabilis*	Bougainvillea	B13
13	*Broussonetia papyrifera*	Toot	B15
14	*Butea monosperma*	Dhak, Palas, Flame of the Forest	B17
15	*Callistemon lanceolatus*	Bottle Brush	C2
16	*Calotropis procera*	Aak	C5
17	*Carissa spinarum*	Karaunda	C6
18	*Cassia fistula*	Amaltas	C7
19	*Cassia siamea*	Kassod	C11
20	*Casuarina equisetifolia*	Whistling Pine, Jangli Saru	C12
21	*Citrus aurantium*	Khatta	C15
22	*Citrus limon*	Nimbu	C16
23	*Cordia dichotoma*	Chota Lasora	C20
24	*Dalbergia sisoo*	Sheesham	D2
25	*Delonix regia*	Gulmohur, Flame Tree	D3
26	*Eucalyptus globulus*	Eucalyptus	E5
27	*Ficus benghalensis*	Banyan Treem Bargad	F1
28	*Ficus benjamina*	Pakur	F2
29	*Ficus elastica*	Rubber Tree	F3
30	*Ficus religiosa*	Peepal	F7
31	*Grevilla robusta*	Silver Oak	G6
32	*Hamelia patents*	Scarlet Bush	H1
33	*Hibiscus rosasinensis*	Jasum	H3
34	*Ixora coccinea*	Rangan	I3
35	*Lantana camara*	Raimuniya	L3
36	*Lawsonia inermis*	Mehndi	L4
37	*Mangifera indica*	Mango, Aam	M5
38	*Melia azadirach*	Bakain	M7

S.No.	Botanical Name	Common Name	S. No. As per CPCB Guidelines
39	*Morus alba*	Mulberry	M13
40	*Nerium indicum*	Kaner	N1
41	*Nyctanthus arbortristis*	Harsinghar	N2
42	*Polyakthia longifolia*	Ashok	P9
43	*Prosopis juliflora*	Vilayati Kikkar, Vilayati	P15
44	*Psidum guajava*	Amrud	P20
45	*Tabernaemontana*	Chandani	T1
46	*Tecoma stans*	Sona Patti	T3
47	*Terminalia arjuna*	Arjuna	T6
48	*Zizyphus mauritina*	Ber	Z1

Table 4-27 **Density, abundance and frequency of occurrence of flora in the Core zone**

S.No	Species Name	Family	Core (Zone I)		
			Frequency	Abundance	Density
1	*Acacia auriculiformis*	Fabaceae	25.00	1.333	33.3
2	*Acacia nilotica*	Mimosaceae	50.00	1.333	33.3
3	*Alstonia scholaris*	Apocyanaceae	41.67	0.600	15.0
4	*Azadirachta indica*	Meliaceae	66.67	2.250	56.3
5	*Callistemon cirtrinus*	Myrtaceae	25.00	1.667	41.7
6	*Cassia siamea*	Fabaceae	33.33	2.000	50.0
7	*Casuarina equisetifolia*	Casuarinaceae	25.00	3.333	83.3
8	*Ceiba pentandra*	Malvaceae	16.67	2.000	50.0
9	*Dalbergia sissoo*	Fabaceae	33.33	0.750	18.8
10	*Delanix regia*	Caesalpinaceae	25.00	1.333	33.3
11	*Eucalyptus leptophylla*	Myrtaceae	41.67	1.600	40.0
12	*Ficus bengalensis*	Moraceae	16.67	1.500	37.5
13	*Ficus religiosa*	Moraceae	25.00	2.333	58.3
14	*Grevillea robusta*	Proteaceae	16.67	1.500	37.5
15	*Leucana leucophila*	Fabaceae	100.00	1.833	45.8
16	*Neolamarckia cadamba*	Rubiaceae	16.67	2.000	50.0
17	*Peltophorumpterocarpum*	Fabaceae	50.00	3.000	75.0
18	*Phyllanthus emblica*	Euphorbiaceae	8.33	3.000	75.0
19	*Plumeria alba*	Apocyanaceae	33.33	1.500	37.5
20	*Polyalthia longifolia*	Annonaceae	41.67	1.200	30.0
21	*Pongamia pinnata*	Fabaceae	50.00	1.333	33.3
22	*Prosopis julifera*	Mimosoideae	58.33	4.857	121.4
23	*Psidium guajava*	Myrtales	16.67	1.000	25.0
24	*Pterocarpus marsupium*	Fabaceae	33.33	2.250	56.3
25	*Roystonia regia*	Arecaceae	33.33	1.750	43.8
26	*Syzygium cumini*	Myrtaceae	25.00	1.667	41.7
27	*Terminalia arjuna*	Combretaceae	25.00	2.667	66.7

Table 4-28 **Density, abundance and frequency of occurrence of flora in the Buffer zone**

S.No	Species Name	Buffer (Zone II)			Buffer (Zone III)			Buffer (Zone IV)		
		Frq	Abu	Den	Frq	Abu	Den	Frq	Abu	Den
1	*Dalbergia sissoo*	33.33	3.667	91.7	33.33	2.250	56.3	50.00	1.667	41.7
2	*Azadirachta indica*	53.33	1.500	37.5	100.00	2.000	50.0	83.33	2.200	55.0
3	*Ficus religiosa*	46.67	1.143	28.6	66.67	1.500	37.5	83.33	1.000	25.0
4	*Pongamia pinnata*	26.67	1.750	43.8	33.33	1.500	37.5	66.67	1.125	28.1
5	*Cassia siamea*	40.00	2.500	62.5	83.33	1.400	35.0	91.67	1.455	36.4
6	*Albizzia lebback*	20.00	3.000	75.0	66.67	1.375	34.4	83.33	1.400	35.0
7	*Leucana leucophila*	60.00	3.000	75.0	91.67	1.455	36.4	100.00	1.500	37.5
8	*Aegle marmelos*	13.33	1.000	25.0	41.67	1.400	35.0	33.33	1.250	31.3
9	*Pterocarpus marsupium*	40.00	2.333	58.3	75.00	1.111	27.8	83.33	1.400	35.0
10	*Eucalyptus leptophylla*	20.00	2.000	50.0	50.00	1.000	25.0	33.33	1.000	25.0
11	*Neolamarckia cadamba*	40.00	1.167	29.2	66.67	1.125	28.1	50.00	1.333	33.3
12	*Polyalthia longifolia*	26.67	3.250	81.3	58.33	1.571	39.3	33.33	1.500	37.5
13	*Prosopis julifera*	20.00	5.333	133.3	66.67	3.000	75.0	83.33	1.800	45.0
14	*Acacia nilotica*	33.33	2.800	70.0	83.33	1.000	25.0	66.67	1.500	37.5
15	*Mangifera indica*	26.67	1.250	31.3	50.00	1.333	33.3	66.67	1.125	28.1
16	*Ziziphus jujupa*	33.33	1.800	45.0	66.67	1.375	34.4	83.33	1.200	30.0
17	*Delanix regia*	20.00	1.000	25.0	50.00	1.333	33.3	41.67	1.400	35.0
18	*Ficus bengalensis*	26.67	1.000	25.0	41.67	1.200	30.0	66.67	1.125	28.1
19	*Pithocelopium dulce*	33.33	1.400	35.0	66.67	1.500	37.5	50.00	1.333	33.3
20	*Alstonia scholaris*	40.00	1.333	33.3	75.00	1.667	41.7	91.67	1.091	27.3
21	*Plumeria alba*	20.00	1.667	41.7	58.33	1.143	28.6	50.00	1.667	41.7
22	*Grevillea robusta*	20.00	1.000	25.0	41.67	1.200	30.0	50.00	1.333	33.3
23	*Phyllanthus emblica*	13.33	1.500	37.5	33.33	1.000	25.0	66.67	1.250	31.3
24	*Peltophorumpterocarpum*	53.33	1.625	40.6	83.33	1.700	42.5	75.00	1.333	33.3
25	*Millingtonia hortensis*	26.67	2.000	50.0	33.33	1.500	37.5	41.67	1.200	30.0
26	*Melia azardirachta*	13.33	2.000	50.0	25.00	1.667	41.7	33.33	1.500	37.5
27	*Psidium guajava*	20.00	1.667	41.7	25.00	1.333	33.3	33.33	2.000	50.0
28	*Syzygium cumini*	26.67	1.500	37.5	58.33	1.143	28.6	50.00	1.000	25.0
29	*Tectona grandis*	33.33	1.600	40.0	75.00	1.556	38.9	91.67	1.182	29.5
30	*Phoenix sylvestre*	46.67	1.143	28.6	66.67	1.625	40.6	50.00	2.000	50.0
31	*Moringa oleifera*	33.33	1.600	40.0	50.00	1.000	25.0	58.33	1.143	28.6
32	*Erythrina indica*	26.67	1.000	25.0	25.00	1.667	41.7	16.67	2.500	62.5
33	*Ficus elastica*	20.00	1.000	25.0	16.67	2.000	50.0	25.00	1.000	25.0
34	*Acacia auriculiformis*	26.67	1.250	31.3	41.67	1.200	30.0	33.33	1.250	31.3
35	*Ailanthus excelsa*	13.33	3.500	87.5	50.00	1.167	29.2	25.00	1.333	33.3
36	*Ceiba pentandra*	26.67	2.750	68.8	33.33	1.500	37.5	33.33	1.250	31.3
37	*Casuarina equisetifolia*	20.00	2.667	66.7	41.67	2.200	55.0	33.33	1.250	31.3
Frq- Frequency; Abu – Abundance ; Den- Density										

4.12.14. Fauna

The capacity to measure the status and any changes therein of animal resources is an elementary requirement for the meaningful assessment. As such there will be limited impact envisaged on the fauna of the area. In view of this, the fauna of the area has been studied based on the literature and independent studies carried out by specialized

agency - Bombay Natural History Society and Classified information about native species collected from the forest department.

Avifauna

In the vicinity of the Effluent Treatment Plant, thriving on treated effluent, an ecological park with lush green cover has been developed in an area of 4.45 acres. The park is a testimony to eco-friendly operations at Mathura Refinery. Mathura Refinery had engaged Bombay Natural History Society (BNHS) to assess biological diversity in the park. During the survey, the experts from the BNHS identified 87 species of birds - including 30 species of migratory birds in the park - indicating richness of life in the ecosystem. Thousands of migratory birds visit this park every year between October - February. The ecological park of Mathura Refinery has been appreciated by one and all. Mathura Refinery has also published a book on the species of birds, which has been appreciated by the Hon'ble Prime Minister of India. List of the avifauna identified in the study is tabulated in Table 4.29.

Table 4-29 List of Bird Species under Avifauna identified in the study Area

S. No.	Bird's Name	Scientific Name
1	Bank Myna	*Acridotheres ginginianus*
2	Barheaded Goose	*Anser indicus*
3	Black Drongo or King Crow	*Dicrurus adsimilis*
4	Black Redstart	*Phoenicurus ochruros*
5	Blue Rock Pigeon	*Columba livia*
6	Blue throat	*Erithacus svecious*
7	Brahminy or Black headed Myna	*Sturnus pagodarum*
8	Cattle Egret	*Bubulcus ibis*
9	Common Grey Hornbill	*Tockus birostris*
10	Common Indian Nightjar	*Caprimulgus asiaticus*
11	Common Sandpiper	*Tringa hypoleucos*
12	Common Swallow	*Hirundo rustica*
13	Common Teal	*Anas crecca*
14	Coot	*Fulica atra*
15	Crow-Pheasant or Coucal	*Centropus sinensis*
16	Darter or Snake-Bird	*Anhinga rufa*
17	Egyptian Vulture	*Neophron perenopterus*
18	Gadwall	*Anas strepera*
19	Garganey or Bluewinged Teal	*Anas querquedula*
20	Grey Heron	*Ardea cinerea*
21	Grey Wagtail	*Motacilla cinerea*

S. No.	Bird's Name	Scientific Name
22	Greyheaded Flycatcher	*Culicicapa ceylonensis*
23	Honey Buzzard	*Pernis ptilorhyncus*
24	Hoopoe	*Upupa epops*
25	House crow	*Corvus splenders*
26	House Sparrow	*Passer domesticus*
27	House Swift	*Apus affinis*
28	Indian Great Reed Warbler	*Acroceohalus stentoreus*
29	Indian Longbilled Vulture	*Gyps indicus*
30	Indian Moorhen	*Gallinula chloropus*
31	Indian Robin	*Saxicoloides fulicata*
32	Indian Shag	*Phalacrocorax fuscicollis*
33	Jungle Babbler	*Turdoides striatus*
34	Jungle Crow	*Corvus macrorhynchos*
35	Laggar Falcon	*Falco biarmicus Jugger*
36	Large Cormorant	*Phalacrocorax carbo*
37	Large Egret	*Ardea alba*
38	Large Grey Babbler	*Turdoides malcoimi*
39	Large Pied Wagtail	*Motacilla*
40	Lesser Whisteling Teal	*Dendrocygna javanica*
41	Lesser Whitethroat	*Sylvia curruca*
42	Little Brown Dove	*Streptopelia senegalensis*
43	Little Cormorant	*Phalacrocorax niger*
44	Little Egret	*Egretta garzetta*
45	Little Grebe or Dabchick	*Tachybaptus ruficollis*
46	Little Green Heron	*Ardeola striatus*
47	Long tailed Nightjar	*Caprimulgus macrurus*
48	Magpie-Robin	*Copsychus saularis*
49	Mallard	*Anas platyrhynchos*
50	Marsh Harrier	*Circus acruginosus*
51	Median or Smaller Egret	*Egretta intermedia*
52	Night Heron	*Nyciticorax nycticorax*
53	Paddy Bird or Pond Heron	*Ardeola grayii*
54	Pied Kingfisher	*Ceryle rudis*
55	Pied Myna	*Sturnus contra*
56	Pintail	*Anas acuta*
57	Purple Heron	*Ardea purpured*
58	Purple Moorhen	*Porphyric porphyrio*
59	Purple Sunbird	*Nectarina asiatica*
60	Red breasted Flycatcher	*Muscicapa parva*
61	Red crested Prochard	*Netta rufina*
62	Red rumped or Striated Swallow	*Hirundo daurica*

S. No.	Bird's Name	Scientific Name
63	Red vented Bulbul	*Phcnonotus cafer*
64	Red wattled Lapwing	*Vanellus indicus*
65	Ring Dove	*Streptopelia decaocto*
66	Roller or Blue Jay	*Coracias benghalensis*
67	Rose ringed Parakeet	*Psittacuala krameri*
68	Shirka	*Accipiter badius*
69	Shoveller	*Anas clypeata*
70	Small Blue Kingfisher	*Alcedo atthis*
71	Small Green Bee-eater	*Mercops orientalis*
72	Spot bill or Grey Duck	*Anas poecilorhyncha*
73	Spotted Munia	*Lonchura punctulata*
74	Spotted Owlet	*Athene brama*
75	Tufted Pochard	*Aythya Fuligula*
76	White throated Munia	*Lonchura malabarica*
77	White Wagtail	*Motacilla alba*
78	White backed or Bengal Vulture	*Gyps bengalensis*
79	White breasted Kingfisher	*Halcyon smyrnesis*
80	White breasted Waterhen	*Amaurornis phoenicurus*
81	White cheeked Bulbul	*Pycnonotus leueogenys*
82	White-Eye	*Zosterops palpebrosa*
83	White-Eyed Pochard	*Aythya nyroca*
84	Wigeon	*Anas penelope*
85	Wiretailed Swallow	*Hirundo smithii*
86	Yellow headed Wagtail	*Motacilla citreola*
87	Yellow Throated Sparrow	*Pertronia-xanthocollis*
88	Yellow Wagtail	*Motacilla flava*

Figure 4-33 Avi-fauna Observed and Recorded during Study

Black Ibis

Bronze winged Jacana

	
Cattle Egret	Common Grey Hornbill
	
Common Moorgan	Common Myna
	
Crow pheasant	Darter

Grey Heron

Indian Robin

Indian Treepie

Purple Heron

Pied Kingfisher

White chested Kingfisher

	
Purple Moorhen	Redwattled lapwing
	
Ring necked Dove	Rose ringed Parakeet
	
Spot billed Duck	White breasted Waterhen

Sur Sarovar Bird Sanctuary

The sanctuary, which is located at 26 km from Mathura Refinery, was set up in 1991 covers an area of 4030 Sq.km and is under Agra Forest division. It offers an ideal home for a large number of aquatic birds - both resident and migratory. A good number of parrots and little doves were also observed on trees around the lake.

Keetham Lake is situated at a distance of 20 km from Agra city in Uttar Pradesh and at adistance of 180 km from Delhi. The entire lake is formed in a catchment area of 7.13 km2. Forest Department and named as Sur Sarovar. Keetham Lake is pentagonal in shape with artificially created islands for shelter and breeding grounds to the migratory birds. More than 106 species of migratory and resident birds are known to have their resting habitats at Sur Sarovar.

The important aquatic birds inhabiting Keetham lake are Little Gerbs, Cormorants, Darter, Grey Heron, Purple Heron, Paddy Bird, Cattle Egrets, Large Egrets, Smaller Egrets, Little Egrets, Night Heron, Indian Reef Heron, Black necked Stork, white Ibis, Spon Bill, Greying Goose, Bar headed Goose, Lesser Whistling Teal, Ruddy Shelduck, Pintail, Common Teal, Spot Billed Duck, Gadwall, Wigeon, Shovler and Comb Duck. The riverine belt of River Yamuna surrounds the area of Sur-Sarovar. The climatic condition of the lake area is typical of Uttar Pradesh plains with hot windy summers and extremely cold winters. The average temperature ranges between 1.5 ^{o}C to 49 ^{o}C. The monsoon season occurs during July to September. Recently, U.P. Forest Department has created woodlands and developed shallow areas near lake, making it a natural habitat for birds nesting sites. The water quality of Keetham lake supports wide range of avifauna during winter season.

Fisheries

Information on fisheries was obtained from fisheries department, Mathura district. Fish Species that are cultured in ponds in study area are *Catla catla, Labeo rohita,* Common Carp, Grass Carp and Silver Carp.

Reptiles and Mammals

Snakes like Water snake, Indian Cobra and Russels Viper are common in this region. Due to patchy nature of dense vegetation mammalian density of this region was observed to be very low Wildlife data pertaining to this region is available. However Mongoose (Schedule II) and Three Striped Squirrels (Schedule IV) were commonly seen during survey.


Reptiles and Mammals recorded during the study visit

Diversity Indices

Following indices were used for estimation of ecological status of this area

1. Shannon's index
2. Margalef's index
3. Simpson's index The indices were applied to woody flora

Shannon' Index

Typically the value of the index ranges from 1.5 (low species richness and evenness) to 3.5 (high species evenness and richness), though values beyond these limits may be encountered. Because the Shannon Index gives a measure of both species numbers and the evenness of their abundance, the resulting figure does not give an absolute description of a sites biodiversity. It is particularly useful when comparing similar ecosystems or habitats, as it can highlight one example being richer or more even than another. There is always the need to inspect the data or use another index to unpack the true reasons for the difference.

$$H' = -\sum_{i=1}^{S}(p_i \ln p_i)$$

Where: where S is the total number of species and p_i is the frequency of the ith species.

The value Shannon's index of study area is minimum in Core area (Zone I) 3.452 (Zone II), 3.524 (Zone III) and 3.531 (Zone IV). Hence, the diversity of this area is good.

Margalef's Index

It is calculated from the total number of species presented the abundance or total

number of Individuals.

Margalef Index (D) = S – 1/ log e N

Where: S – total number of species, N – total number of individuals

The higher the index the greater is the diversity. The value of Margalef's index for woody flora were observed to be 3.376, 4.584, 4.762 and 4.799 for Zone I, Zone II, Zone III and Zone IV respectively.

Simpson's Index

Simpson's Index measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species).

Simpson's Index $\lambda = \sum n(n-1)/N(N-1)$

Where: n – total individuals of each species

N – total individuals of all species

With this index, 0 represents infinite diversity and 1, no diversity. That is, the bigger the value of D, the lower the diversity. This is neither intuitive nor logical, so to get over this problem, D is often subtracted from 1 to give:

Simpson's Index of Diversity 1 - **λ**

The value of this index also ranges between 0 and 1, but now, the greater the value, the greater the sample diversity. This makes more sense. In this case, the index represents the probability that two individuals randomly selected from a sample will belong to different species. Simpson index values of woody flora was very close to 1 (0.87) indicating uniform distribution of species.

The values of Simpson index for woody flora were observed to be 0.952, 0.965, 0.969 and 0.970 for Zone I, Zone II, Zone III and Zone IV respectively.

Table 4-30 Biodiversity Indices of the Study Area

S.No	Study area Zone	Dominance_D	Simpson_ 1-D	Shannon_H	Evenness_ e^H/S	Margalef Index
1	Zone I -core Zone	0.048	0.952	3.124	0.909	3.376
2	Zone- II Buffer	0.035	0.965	3.452	0.902	4.584
3	Zone- III Buffer	0.031	0.969	3.524	0.969	4.762
4	Zone- IV Buffer	0.030	0.970	3.531	0.976	4.799

4.13. Socioeconomic Environment

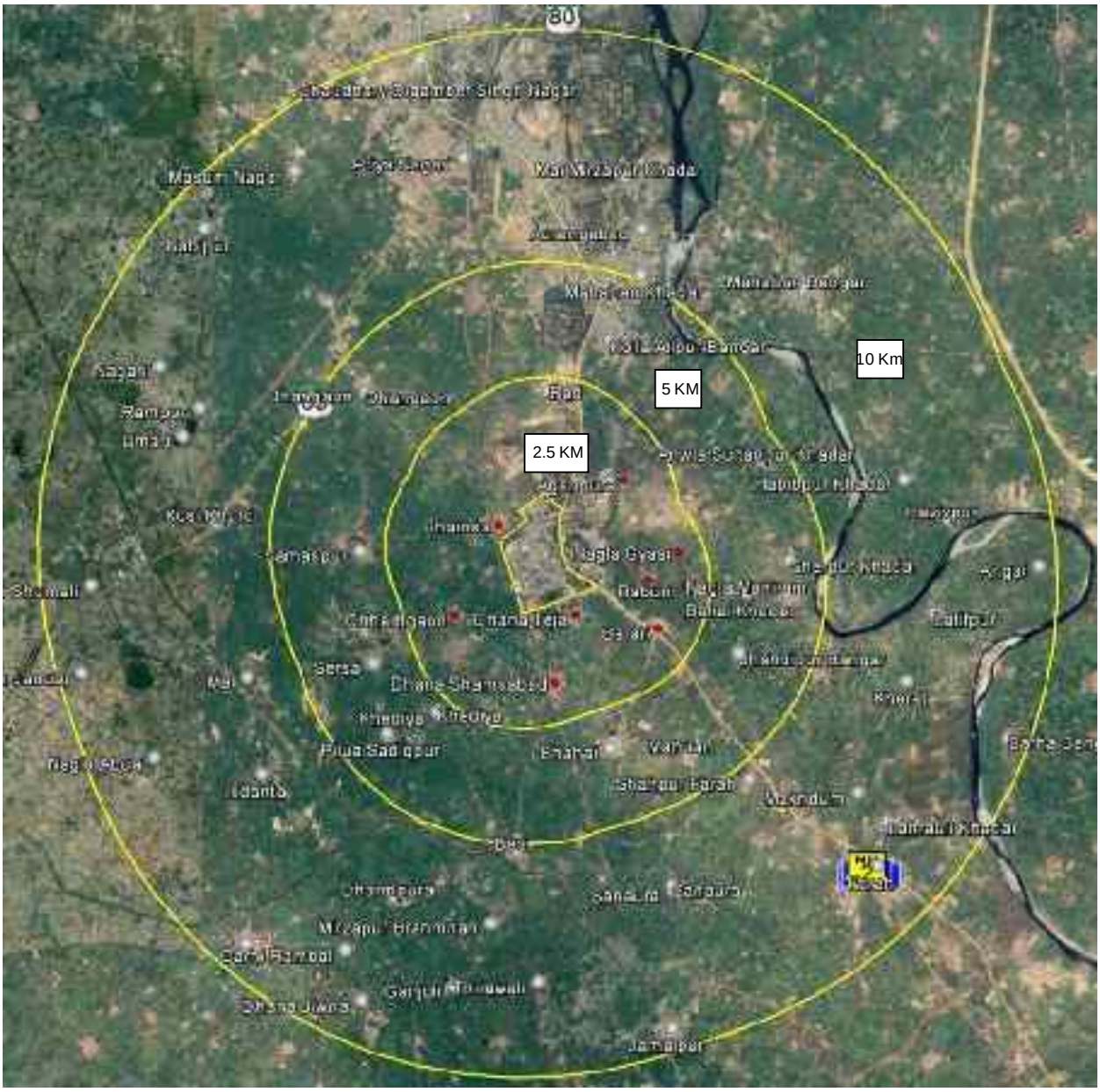
The quality improvement is proposed to be developed within the existing factory premises and does not require any additional land and thus does not attract any Rehabilitation and Resettlement activity under "*Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013".* However to map the socioeconomic conditions of the local people the villages falling within the 10km radius of the project site is considered. Based on Directorate of Census Directorate, there are about 99 revenue villages and 4 Census towns. Apart from the study area villages the 9 villages (Anganpura, Baburi Garbi, Baburi Sharqi, Barari, Bhainsa, Chharhgaon, Dhana Shamsabad, Dhana Teja, Nagla Maniram) falling within 2 km from the project site is considered for primary survey. Table 4.30 shows the administrative structure of the study area. List of Villages in the study area is listed in *Annexure-20.*

Table 4-31 Administrative Status of Study Area Villages/Towns

S.No	State	Sub-District	No. of Villages
1	Rajasthan	Kumher	1
2	Uttar Pradesh	Mahavan	22
3		Mathura	80
Total			103

Source: Census 2011

Figure 4-34 Google Image showing the Study Area villages



Source: Google Earth, Image Dated 03/03/2017

4.13.1. Socioeconomic Indicators considered for the Study

For the purpose of this study, socioeconomic indicators such as demography, literacy, health, livelihood, amenities and cultural aspects were collected. Secondary Published data such as population and amenities obtained from Directorate of Census Operations, Health indicators such as immunization levels, institutional births from District Level Household survey-3, Households under Poverty line and Households availing safe sanitation details are collected from Baseline Survey-2012, published by Ministry of Drinking Water and Sanitation.

4.13.2. Primary Survey

Primary Survey was undertaken from 31st Jan 2017 to 3rd Feb 2017. During this survey, primary data in relation to geographical features, settlements, roads and amenities in the respective villages were observed. In addition to the site observations, informal focused group discussion was conducted in the villages falling within 2.5km of the project site. The discussion was mainly focused on mapping the existing amenities in the respective villages, felt basic needs, Problems if any due to the existing project operation. The discussion was carried out with the village representatives, farmers, etc who have good knowledge about the village and happenings.

Figure 4-35 Reconnaissance and Primary Survey

Study Team – IOCL Mathura Refinery Gate

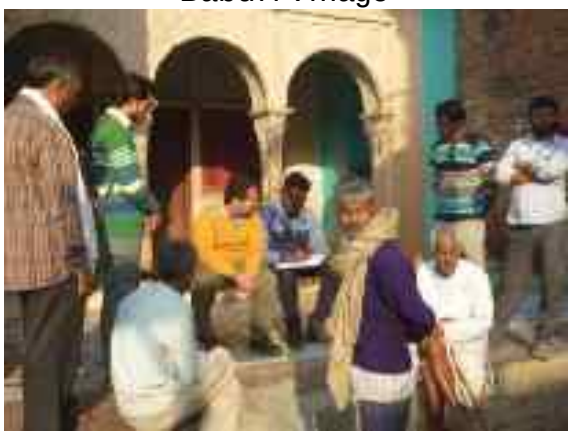
Aganpura Village

Baad Village

Bainsha Village


Baburi Village


Dana Teja Village


Dhana Shamsabad Village


Chargoan Village


Kesava Deo Temple -Krishna

4.13.3. Regional Socioeconomic Profile

The project study area falls in the district of Mathura, Uttar Pradesh State. Mathura District is situated on the banks of Yamuna River. Mathura City the historic town named to be the birth place of Lord Krishna is the District Headquarters. Mathura district is part of Agra division among 18 divisions of Uttar Pradesh. In 2011, the district's total population was about 25.4 lakhs with the 167th highest populated city in the country. The population density of the district is about 761/sq.km and is less with the Uttar Pradesh state rate of 829/Sq.km. The population growth rate in the past decade (2001-2011) was 22.5%. The male to female sex ratio in the district was about 858 females for 1000 males. The literacy rate is about 73% and the rate higher than the rate of Uttar Pradesh state (68%). Mathura is dominated by Yadav community. Traditionally the Yadav community was linked to cattle rising and associated works and

gradually the occupation pattern changed to cultivation. Braj Bhasha is the mostly spoken language in the district and the language is termed to be language of Lord Krishna. The climatic condition in the district seems to very hot (44^{o}C) in the summer and cold and foggy winters where temperature dipping up to 5^{o}C. The major sources of the economic activity in the district are industries and agriculture. Some of the major industries in district are Mathura refinery and Textile printing industries. Whereas agriculture and animal husbandry plays an important role in the livelihood of the people Agriculture is carried in three different seasons namely Kharif, Rabi, Zaid. Bajra, Paddy, Til, Arhar and Maize are grown in kharif season while Wheat, Barley, Rai-Sarson and Potato are grown in rabi season and during Zaid, Cotton, Moong, Green Fodder and Vegetables were grown. The culture in the region however influenced by urban culture, the tradition and practice of the people are mostly centered towards the Lord Krishna and its tales. The people in the region are called Brijiwasi and the place is famous for the sweets and snacks made of milk. Tourism plays an important role in the livelihood of the city as there are number of tourist attractions which induces livelihood opportunities in the city. The mathura is well connected with transportation facilities like train and bus and the nearest International Airport is at 170 km.

4.13.4. Socioeconomic Profile of Study Area

4.13.4.1. Demographic and Culture

Cumulative population in the study area is 2,57,456 with 1,37,498 males and 1,19,958 females, which is only about 10.1%% of the District's population. The children population below 6 years old was found to be 41,893 which are of about 16.2% of the total population. District's Population density is 763 per square kilometer as compared to State 829. The Sex Ratio was found at 872 females per thousand males, with that of District's ratio of 912. The Sex ratio of the children was about 859. The Vulnerable populations such as Scheduled Caste and Scheduled Tribes population were 24.3% and 0.02% respectively. With respect to the living conditions of the study area villages most of the people are living in semi pakka and pakka houses and very few katcha houses are observed. However status of the roads and drainage systems in the villages are in poor conditions. The study area is mostly agrarian culture with most of the rural population are involved in agriculture and allied activities. Most of the people are dependent on

agriculture and allied activities. Village wise demographic indicators are depicted in *Annexure-20.*

Settlements at Baad Village

Settlements at Bainsa Village

Settlement at Nagalagesi Village

Settlements at Chargoan Village

4.13.4.2. Economic Indicators

4.13.4.2.1. Population Under Below Poverty Line

Below Poverty Line (BPL) is an economic benchmark of any particular area. Higher the rate of BPL family, lower is the prosperity of the area. Baseline survey report of Ministry of Drinking water and Sanitation indicated that an average of 15.5% population in the study area falls under BPL category. However the range of households under poverty line ranges from 0.6% to 61.7%. The rate of BPL households in the villages falling within 2.5 km radius of the project site is about 20%. However the secondary data reports showing the rate of BPL households to be less it was observed during the primary survey that the living status of the people seems to very poor. The village wise rate of BPL Households is mentioned in the *Annexure-20.*

4.13.4.2.2. Agriculture

The major source of livelihood in the study area is agriculture and Animal husbandry. In the study area the agriculture is carried out in two major seasons namely Kharif and Rabi. The major source of rainfall for the region is through South-West monsoon. The major source of irrigation in the region is through Canals and Bore-wells. The Crop intensity in the district was 140%. The major crops produced in the region are Wheat, Rice, Rapeseed mustard, Bajra, Potato, Barley, Onion, etc. However the villages adjacent to the Refinery are mostly dependent on refinery and mostly doing labor works. As majority of the land was sold to refinery and no major parcel of land left out for agriculture. The villagers also employed as Agriculture labors in the adjacent villages.

Fodder Crop Cultivation

Wheat Cultivation

Potato Cultivation

Animal Husbandry

4.13.4.2.3. Employment and Livelihood

According to Census 2011, the percentage of working population in the study area was 29.4% and as against the state's level percentage was 32.9%. 73% of the working populations are main workers, shows the improved employment activity as they are employed for more than 6 months in the year. About 47.04% of the total working

population in the study area was engaged in agricultural activity. The agricultural workers group is sub-grouped into Cultivators and Agricultural Labors. In which 55% were cultivators and 45% were Agricultural Labors. Household Industry relates to production, processing, servicing, repairing or making and selling of goods. Other workers are all workers who have been engaged in some economic activity like employed in industries, fishing activity, wagers, construction workers, etc., but are not cultivators or agricultural laborers or Household Industry. The percentage of Household and Other workers group were 4.2% and 49% respectively. Based on the census records of the study area villages it is clearly evident that the majority of the population in the region is involved in agriculture activity and other workers category. With respect the villages adjacent to the study area the majority of the population are involved in industrial and allied works only as there are no agriculture lands left out for cultivation and some of the people also involved in agriculture labor works from the nearby villages.

4.13.4.3. Health Indicators

With respect to Government Health facilities in the district there are about 39 allopathic hospital with 1706 bed facility, 34 Ayurvedic hospital, 7community health centre, 29 primary health centres, 10 primary health sub-centers and 215 private hospitals. Based on the *'District level Household survey – 3'* published by Ministry of Health & Family Welfare, the Institutional Birth Rate was about 39.9%. The childhood immunization was to be only 20.4%. About 20.9% of the pregnant women availed full antenatal care. With respect to the villages adjacent to the refinery there are no medical facilities within any of the villages. Mostly people are going to S.J.Hospital and private clinics in case of ailments. The nearest major health facilities are available at Mathura city. S.J. Hospital is run by IOCL Mathura at free of cost for the local public and medicines are sold at generic prices. There are no major health problems reported by the people except Arthritis, Diabetes, common cold and fever, etc.

	
Swarn Jayanti Samudyaik Hospital , Mathura	Private Clinic at Barai Village
	
Ayudrvedic Hospital at Baad Village	Anganwadi at Baburi Village

4.13.4.3.1. Drinking Water and Sanitation Facilities

The main source of Drinking water in the study area is through Borewell and Hand Pump. And most of the places the ground water is not fit for drinking and became saline so most of the people depend on the public distribution channels where the drinking water were supplied by scheduled time and mostly accessible by distance place from the residence. Based on the District level household survey-3, 85% of the district population is accessed through improved source of drinking water facility and 29.7% of them accessed to toilet facility. Based on the Baseline Survey 2012 published by Ministry of Drinking water and Sanitation, 22.3% of the households in the study area villages are accessed to safe sanitation facilities and the rate of people accessed to safe sanitation facility is less in the villages adjacent to the project site (17.8%). The village wise percentage of sanitation facility is depicted in *Annexure-20.*

	
Drinking water source at Baad Village	Women from Aganpura Village Collecting Drinking water
	
Drianage flowing on roads – Baad Village	Drainage flowing in Chargoan Village

4.13.4.4. Education Indicators

In the study area about 73% of the total populations are literates, which is slightly higher than state's literacy rate of 67.68%. In Mathura district 70.7% of the children (aged 7plus) are literate and 97.2% of the girl children (aged 6 to 11) attending school. (Ref- [2]). The rate of male literacy rate (81.5%) is more when compared with the female literacy rate (74.3%). Most of the villages in the study area are having primary schools within the village, Middle schools and High schools are available within the respective Panchayat. Higher education facilities such as colleges are present in Mathura City. The village wise literacy rates in the study area are depicted in the *Annexure-20.*

[2] District Level Household Survey (DLHS -3)


Secondary School – Baburi Village


Primary School – Bainsa Village


Secondary School – Barai Village


Middle School – Nagalakesi Village

4.13.5. Socioeconomic Aspects

4.13.5.1. Summary Socioeconomic Indicators

Table 4-32 **Summary Socioeconomic Indicators of the Study Area**

S.No	Particulars	Study Area	Uttar Pradesh
1	Study Area	99 Revenue Villages and 4 Census Towns (1 Village from Bharatpur District, Rajasthan)	Mathura District
2	Total Households	43,345	3,34,48,035
3	Total Population	2,57,456	199812341
4	Sex Ratio	872	912
5	Children Population (<6 Years Old)	41,893	3,07,91,331
6	Children Sex Ratio	859	902
7	Urban Rural Ratio	21:79	22:78
8	SC Population	24.3%	20.69%
9	ST Population	0.02%	0.56%
10	Age at Marriage – Male	22	21.6

S.No	Particulars	Study Area	Uttar Pradesh
11	Age at Marriage – Female	18	18.4
12	BPL Households	15.5%	37.7%
13	Working Group Population	29.4%	32.93%
14	Main Workers	73%	67.81%
15	Marginal Workers	27%	32.18%
16	Agricultural Workers	47%	59.25%
17	Household Industries	4.2%	5.92%
18	Other Workers	49%	34.82%
19	Institutional Birth Rate	39.9%	24.5%
20	Childhood Immunization	20.4%	30.3%
21	Sanitation Facilities	22.3%	35.24%
22	Literacy Rate	73%	67.68%

5. ASSESSMENT OF ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

5.1. General

The chapter presents identification and appraisal of various impacts due to the proposed QIP project during construction and operational phases. The environmental impacts are categorized as primary and secondary. Primary impacts are those, which are attributed directly to the project and secondary impacts are those, which are indirectly induced and typically include the associated investment and changed pattern of social and economic activities by the proposed action.

5.2. Impacts and Mitigation Measures during Construction Phase

This includes the following activities related to levelling of site, construction and erection of plant components. As the main impacts of the construction phase are envisaged in terms of air pollution only, this natural mitigation would be significantly helpful in elimination of predicted impacts of the phase.

5.2.1. Land use and Soil Quality

The construction activities of new installation will not necessitate any land acquisition. As the proposed project is only a Quality improvement program, the proposed equipments will be installed within the existing facility. There will be no major impacts on soil quality.

5.2.2. Air Quality

5.2.2.1. Impacts

The sources of emission during the construction period are the movement of equipment at the construction site and dust emitted during erection of plant related activities. The dust emitted during the above mentioned activities depend upon the ambient humidity levels. Temporary increase in air pollution will result from the use of construction equipments, and fugitive dust. Due to the short duration of the planned action, any impacts on ambient air quality during construction activities are expected to be short term.

5.2.2.2. Mitigation Measures

- The entire construction activities will be confined with the designated area inside the existing premises
- Transport vehicles and construction equipment / machineries will be properly maintained to reduce air emissions
- Equipment will be periodically checked for pollutant emissions against stipulated norms
- Exhaust vent of DG set will be kept at proper height to ensure quick dispersion of gaseous emissions
- Sprinkling of water on roads and construction site, sufficient vegetation are some of the measures that would greatly reduce the impacts during the construction phase.
- Implementing proper upkeep and maintenance of vehicles, Pollution under Control (PUC) certified vehicles will be used for transporting machinery.

5.2.3. Noise Environment

The major sources of noise during the construction phase are vehicular traffic and construction activities. The operation of these equipments will generate noise ranging between 85-100 dB (A) near source. These noises will be generated mostly within the existing plant boundary and will be transient in nature. Due to existing green cover all around the periphery of the plant boundary, these noise levels will be attenuated to a large extent and are not likely to have any significant impact on the nearby villages. Overall, the impact of noise due to construction on the environment is likely to be insignificant, reversible and localized in nature.

5.2.4. Water Quality

The peak requirement of water during construction will be supplied from the existing water system. The construction equipment is more related to mechanical fabrication, assembly and erection. Temporary sanitation facilities (soak pits/septic tanks) will be set up for disposal of sanitary. Sewage generated by the work force as per the prevailing labour laws. Since most of the construction work force will consist of floating

population, the demand for water and sanitation facilities will be low and it will be managed by the existing water supply system and additional sanitation.

5.2.5. Terrestrial Ecology

The impact on land environment during construction phase shall be due to generation of debris/construction material, which shall be properly collected and disposed off. However, being the modifications limited to existing area, the generation of such waste shall be minimal.

5.2.6. Demography and Socio-Economics

There is no rehabilitation and resettlement for the proposed project site since the proposed expansion will be in the existing plant premises. During construction phase of the project, this project will provide temporary employment to many unskilled and semi skilled labour for erection and movement of material.

5.3. Impacts and Mitigation during Operational Phase

The following activities related to the operational phase will have varying impacts on the environment and are considered for impact assessment:

- Air Quality-Point source emissions and associated environmental impacts
- Solid and Hazardous Waste -collection, storage and disposal practices
- Noise Levels
- Ecological and Biological Environment
- Socioeconomic Impacts

5.3.1. Land Use

The proposed project involving QIP is within the plant premises; hence, there will not be any change in the land use pattern in the study area due to the proposed the propose project.

5.3.2. Air Quality- Point Source Emissions

The major pollutants from the proposed quality improvement will be sulphur dioxide (SO_2) and Oxides of Nitrogen (NO_x). The main source of pollution is due to emissions from proposed units and revamps.

Prediction of impacts on air environment has been carried out by employing

mathematical model based on a steady state Gaussian Plume Dispersion Model designed for multiple point sources for short term. In the present case, ISCST3 dispersion model, designed for multiple point sources for short term has been used for simulations from point sources. The model simulations deal with dispersion of additional Sulphur dioxide (SO_2) emission from the stacks.

Table 5-1 Basis for the Air Quality Modelling Inputs

Parameters	Units	Stack (Prime G Revamp)	Stack 2 (CCRU)	Stack 3 (ISOM)	Stack 4(DHDS Revamp)
Fuel Consumption	MMKcal/ hr	1.8	29.2	3.2	1.6
Stack Height	m	60	67	45	44
Stack Tip Diameter	m	0.7	2.2	1.5	1.52
Exit Gas Velocity	m/s	7.1	10.3	3.5	3.6
Exit gas temperature	^{0}C	366	210	205	190
Stack Flue Gas Quantity	Nm^3/hr	4300	61000	12000	4400
SO_2 Emissions	mg/Nm^3	15	15	15	15
SO_2 Emissions	Kg/hr	0.064	0.92	0.18	0.06
NO_x Emissions	mg/Nm^3	155	60	120	110
NO_x Concentration	Kg/hr	0.66	3.66	1.44	0.48
Particulate Matter	mg/Nm^3	5	9.6	8.5	8.5
Particulate Matter	Kg/hr	0.02	0.16	0.028	0.01

5.3.2.1. Prediction of Air Quality Impacts – Sulphur Dioxide

The peak predicted 24 hr Ground level Concentrations of sulphur dioxide will be in order of 0.27 $\mu g/m^3$ and such concentrations will occur within in the plant boundary.

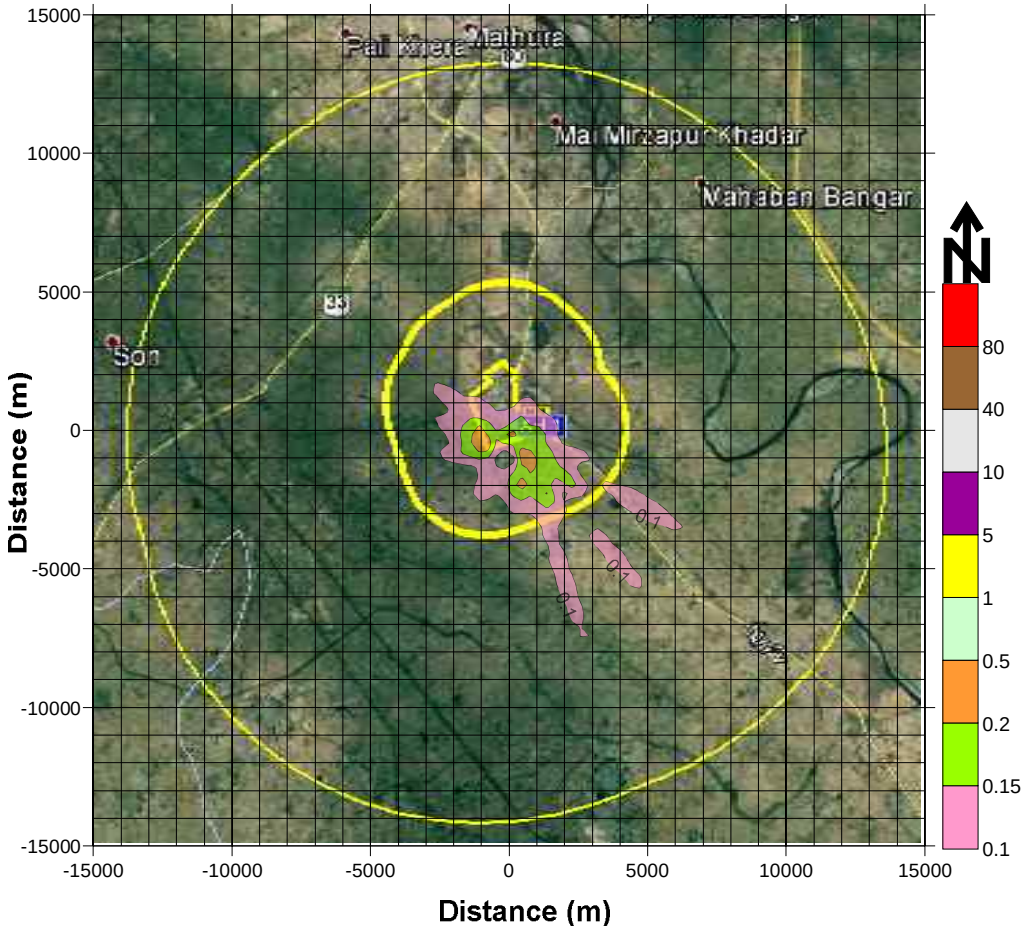
The predicated concentrations were found to be insignificant which will be get diluted rapidly. The envisaged resulting concentrations during proposed project in the downwind villages will be in the range of 10.74$\mu g/m^3$ to 14.97$\mu g/m^3$. Thus the envisaged pollutant concentrations are within the limits of NAAQ standards which are presented in Table 5.2. The isopleths illustrating the dispersion phenomenon of Sulphur dioxide is shown in Figure 5.1.

Table 5-2 Estimated Resultant GLC's Sulphur Dioxide

Code	Station	Direction*	Aerial Distance from Stack (in km)	Sulphur dioxide (SO_2) (µg/m^3)		
				GLCs	Average Baseline concentration	Post project concentration
AAQ1	S.J. Hospital	N	4.3	0.02	12.8	12.82
AAQ2	Gyasi Nagla	E	2.8	0.03	13.1	13.13
AAQ3	Dhana Teja	SE	0.4	0.13	11.6	11.73
AAQ4	Chharhgaon	SW	2	0.07	14.9	14.97
AAQ5	Barari	SE	1.9	0.16	11.8	11.96
AAQ6	Dhana Shamsabad	S	2.5	0.07	11.0	11.07
AAQ7	Bhahai	S	4	0.04	10.7	10.74
AAQ8	Farah	SE	9.2	0.01	11.0	11.01

*with respective to the plant site

Figure 5-1 Predicted 24 hrs Avg. GLC's of SO_2 within 10 km radius of the Study area



5.3.2.2. Prediction of Air Quality Impacts – Oxides of Nitrogen

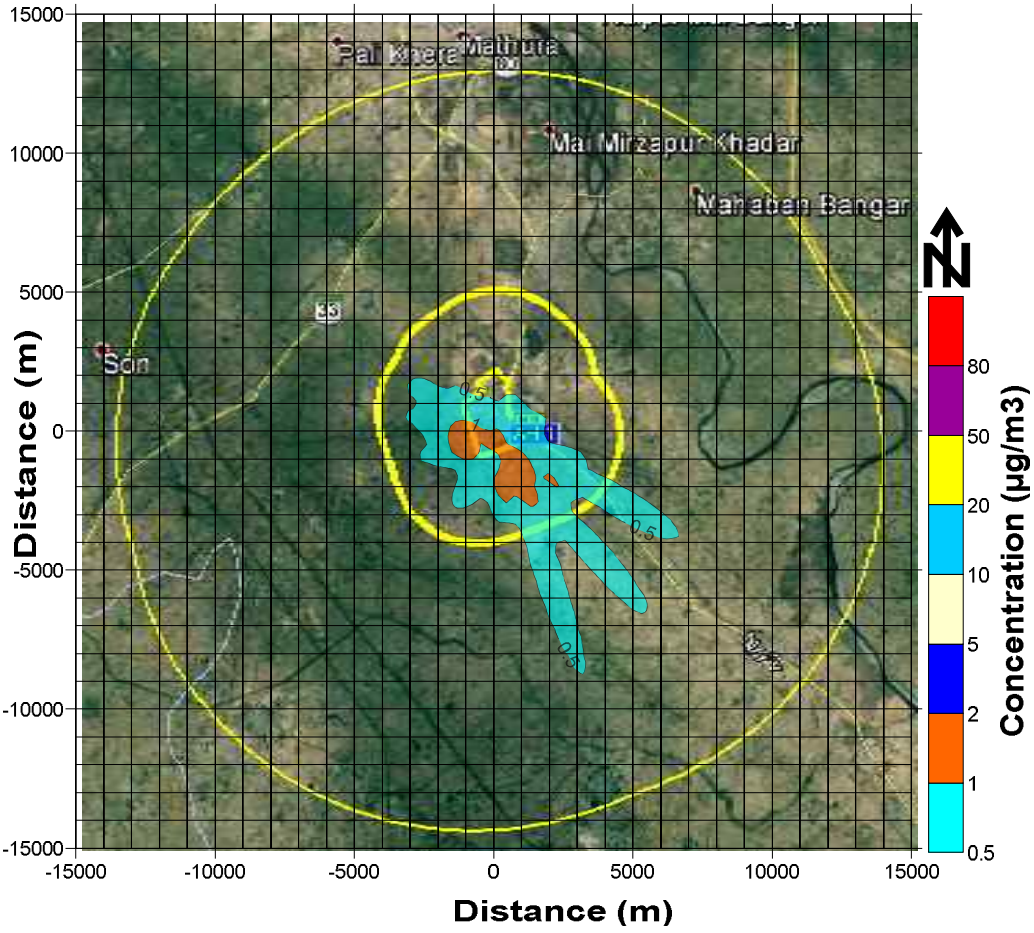
The peak predicted 24 hr Ground level Concentrations of oxides of Nitrogen will be in order of 1.87µg/m^3 and such concentrations will occur within in the plant boundary.

The predicated concentrations were found to be insignificant which will be get diluted rapidly. The envisaged resulting NOx concentrations during proposed project in the downwind villages will be in the range of 20.71µg/m^3 to 24.25µg/m^3. Thus the envisaged pollutant concentrations are within the limits of NAAQ standards which are presented in Table 5.3. The isopleths illustrating the dispersion phenomenon of Oxides of Nitrogen (NOx) is shown in Figure 5.2.

Table 5-3 Estimated Resultant GLC's of Oxides of Nitrogen

Code	Station	Direction with respective to the plant site	Aerial Distance from Stack (in km)	Oxides of Nitrogen (NO_x) (µg/m^3)		
				GLCs	Average Baseline concentration	Post project concentration
AAQ1	S.J. Hospital	N	4.3	0.11	20.6	20.71
AAQ2	Gyasi Nagla	E	2.8	0.23	22.0	22.23
AAQ3	Dhana Teja	SE	0.4	0.95	22.0	22.95
AAQ4	Chharhgaon	SW	2	0.45	21.6	22.05
AAQ5	Barari	SE	1.9	0.65	23.6	24.25
AAQ6	Dhana Shamsabad	S	2.5	0.41	21.9	22.31
AAQ7	Bhahai	S	4	0.25	21.3	21.55
AAQ8	Farah	SE	9.2	0.11	20.7	20.81

Figure 5-2 Predicted 24-Hrs GLC's Avg. of NOX within 10 km Radius of the Study Area



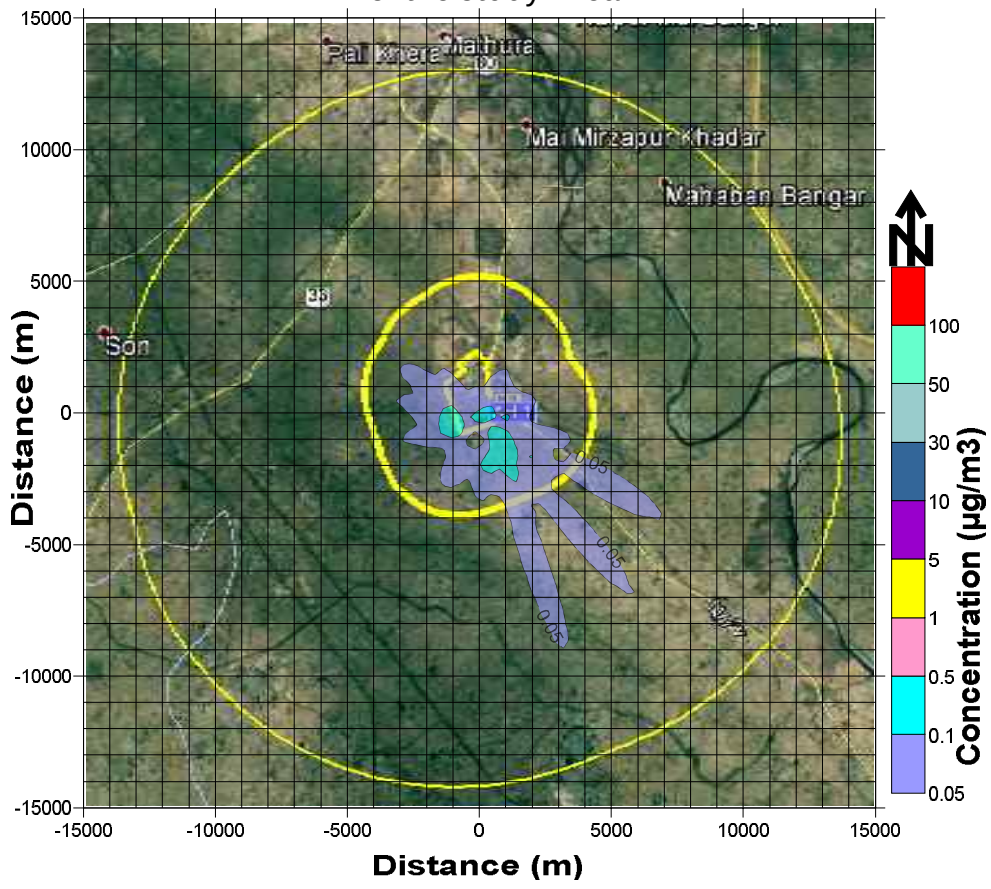
Prediction of Air Quality Impacts - Particulate Matter (PM)

The peak predicted 24 hrs GLC of particulate matter is in the order of 0.15µg/m^3 and such concentrations may occur within the plant boundary. The concentrations were found to get diluted rapidly within the plant boundary and diminished to insignificant raise. The envisaged resulting concentrations during post project in the down-wind settlements will be in the range of 79.53µg/m^3 to 92.07µg/m^3. Thus the envisaged pollutant concentrations are below the prescribed NAAQ Standards which are presented in Table 5.4. The isopleths illustrating the dispersion phenomenon of particulate matter is shown in Figure 5.3.

Table 5-4 Estimated Resultant GLC's of Particulate Matter

Code	Station	Direction with respective to the plant site	Aerial Distance from Stack (in km)	Particulate Matter (PM) (µg/m³)		
				GLCs	Average Baseline concentration	Post project concentration
AAQ1	S.J. Hospital	N	4.3	0.01	85.2	85.21
AAQ2	Gyasi Nagla	E	2.8	0.02	89.7	89.72
AAQ3	Dhana Teja	SE	0.4	0.07	92.0	92.07
AAQ4	Chharhgaon	SW	2	0.03	79.5	79.53
AAQ5	Barari	SE	1.9	0.06	88.7	88.76
AAQ6	Dhana Shamsabad	S	2.5	0.04	82.6	82.64
AAQ7	Bhahai	S	4	0.02	89.2	89.22
AAQ8	Farah	SE	9.2	0.01	90.0	90.01

Figure 5-3 Predicted 24-Hrs Avg. GLC's of Particulate Matter within 10 km Radius of the Study Area



5.3.3. Summary of the Air Quality Modeling Results

Based on the findings of the detailed air quality modeling exercise, it has been inferred that the resultant cumulative concentration at around 10 Kms radius distance from proposed project will comply with the NAAQ Standards. Since there are no ecologically sensitive locations present around the proposed Project site, environmental risks due to release of emissions from the proposed process units will be insignificant. The summary of the predicted GLC's is predicted in **Table 5.5.** The ISCST3 Modelling input and output files of 24 hours peak prediction concentrations of SO_2, NO_X, PM is attached as **Annexure 21.**

Table 5-5 Summary of the predicted GLCs

Parameter	Peak Average Baseline concentration (µg/m³)	Peak Predicted GLCs (µg/m³)	Envisaged Peak Resultant concentration (µg/m³)
PM_{10}	92.0	0.15	92.15
SO_2	23.6	0.27	23.87
NO_X	14.9	1.87	16.77

5.3.4. Noise Emissions and Compliance Status

IOCL has considered installing low noise generating equipment wherever applicable as per the recommended standards and guidelines. Some of the major noise generating equipment will be housed inside the room with an average wall thickness of 230 mm to attenuate noise emissions. According to the Noise Control Handbook (ref)[3], a 230 mm brick wall will provide a noise reduction level of about 20 dB(A) to 25 dB(A) across the wall.

According to the environmental regulations, industrial facilities should adopt sound noise abatement and control programme to meet the following criteria. Sound pressure levels at the property boundary should be less than 55 dBA during daytime hours and 45 dBA during night time hours. Noise levels near the work-zone areas should comply with a maximum permissible level of 85 dBA.

5.3.5. Water Environment

Fresh water required for IOCL Mathura refinery is sourced from Yamuna River and artificial reservoir - Keetham. Plant records have confirmed that the total water demand

[3] *Acoustics and Noise Control Handbook for Architects and Builders, Leland K. Irvine Roy L. Richards*

in the entire IOCL refinery complex and its supporting facilities - including colony and supporting facilities is 669m^3/hr. Additional water required for the QIP is 18m^3/hr which is met from the recycling of treated effluent. No additional water is sourced / required for the proposed QIP and there will be no impact on fresh water resources. Water requirement are QIP is presented in Table 5.6.

Table 5-6 Water Requirement and Wastewater Recycle for Existing and Post Project

S.No	Category	Unit	Existing	Post QIP	Remark
1	Fresh Water Requirement	m^3/hr	669	669	No change in fresh water requirement
2	Wastewater discharge	m^3/hr	176	169	Increased wastewater recycling through new Filtration system at ELR.
3	Treated wastewater recycling	m^3/hr	402 (70%)	413 (71%)	

5.3.6. Wastewater Discharge

IOCL is making its efforts to decrease the wastewater generation through recycling of treated wastewater. After QIP the wastewater discharge will be decreased from 176m^3/day to 169m^3/day. IOCL is installed with robust wastewater treatment systems through which 413m^3/day of wastewater is recycled to the various processes in the refinery.

5.3.7. Solid and Hazardous Waste

The impact on land environment during operational phase shall be due to disposal of solid and hazardous waste generated during operation. There shall be marginal additional generation of spent catalysts from proposed process units. The oily sludge generated from new tanks shall be disposed along with the existing sludge, posing no major impact on land environment. The solid waste (hazardous/ non hazardous) generated during this phase shall be disposed to identified authorized disposal agency. The additional water required for the proposed modernisation project will be met by recycling the treated effluent and hence, no additional water is required to be withdrawn from the existing water source of Yamuna River.

5.3.8. Ecological impact

The predicted ground level concentrations of SO_2 confirmed that insignificant rise in background air quality has been envisaged. Therefore the impact on ecology and biodiversity due to the release of marginal additional emissions from the additional units are insignificant. Treated effluents shall be suitably treated, there shall be no significant impact on fresh water ecology is expected.

5.3.9. Socioeconomic Impact

The proposed is to be developed within the existing factory premises and does not require any additional land for the said quality improvement project and thus does not attract any Rehabilitation and Resettlement activity under *"Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013"*. The impacts includes number of beneficial impacts such as increased number of employment opportunities, Medical facility run by Refinery, increased income level of the people through various indirect business opportunities, etc. Some of the key observations related to lack of facilities or people's basic needs are illustrated below.

- Sanitation Facility in all the villages adjacent to the project site can be enhanced
- Majority of the people adjacent to the project site is dependent on labor works directly or indirectly dependent on Refinery.
- Majority of the drinking water source is through bore-well where the quality of the water is not fit for drinking
- Most of the villages are deprived to basic medical facilities and are accessed at the average distance of 5 km at Mathura refinery hospital.
- Most of the villages are having only primary education facilities and children moving to nearby villages for accessing higher education. The schools are mostly deprived with basic facilities such as proper sanitation facilities, drinking water facilities, approach roads to schools, etc.
- The agriculture is mostly dependent on Bore-well and canals for irrigation and most of the places it was felt there are need for improvement in irrigation facilities

6. ANALYSIS OF ALTERNATIVES

6.1. Introduction

Indian Oil Corporation Limited (IOCL) proposed the quality improvement program and for this purpose, a comparative analysis of various alternatives was considered to avoid or minimize the impacts that would be inevitable in the process. The process of analysis involves identifying the constraints, avoiding activities causing adverse impact and maintaining the economic feasibility.

The range of alternatives selected for the purpose of analysis includes:

- Site alternative
- Technology alternative

6.2. Site Alternative

No additional Land is required for the proposed project. Revamp of existing units shall be carried out in the plot area of existing Prime-G, HGU-1 and DHDS units. New units CCR and ISOM will be installed in the available bare land at southern side of existing refinery plot area.

Hence, there is no site alternatives considered since the proposed project only involves quality improvement, addition and replacement of existing equipments.

6.3. Technology alternative

6.3.1. Present Technology

Presently, following major streams produced from various process units of Mathura refinery are blended in different proportions to produce the Motor Spirit (MS).

- Isomerate from PENEX Unit
- Treated gasoline from prime G Unit
- Heavy Reformate from Catalytic Reforming Unit.

Both Isomerate and Heavy Reformate streams of MS are almost free of any sulphur content. However, sulphur content of Gasoline remains around 100 ppmw .As current sulphur specification of MS of BS-IV specification is 50 ppmw, hence, Mathura Refinery is currently able to produce the MS meeting BS-IV specifications by blending all above specified MS Streams.

However, as per the specification of BS-VI received from Centre of High Technology (CHT), total sulphur content in MS pool shall be 10 ppmw. Hence, in order to produce BS-VI compliant MS from Mathura Refinery considerable reduction in the sulphur content of Gasoline stream would be required.

Similarly, following major streams produced from various process units of Mathura refinery are blended in different proportions to make High Speed Diesel(HSD) complying the BS-IV specifications.

a) Diesel from Hydro Cracker Unit (OHCU).
b) Diesel from Diesel Hydro Desulphurization Unit (DHDS)
c) Diesel from Diesel Hydro Treatment Unit (DHDT).

Both diesel streams produced from OHCU and DHDT contain the sulphur of around 10 ppmw. However, sulphur content of diesel stream produced from DHDS remains around 50 ppmw. As current sulphur specification of HSD complying the BS-IV norms is 50 ppmw, hence, Mathura Refinery is currently able to produce the HSD meeting BS-IV specifications by blending all above mentioned diesel Streams.

6.3.2. Current Technology to be Adopted

As per the Auto Fuel Quality Vision Policy 2025 and communication by MoP&NG on 22nd May'15, it has been directed to implement 100% BS-VI compliant Auto fuels (MS&HSD) w.e.f. 1st Apr'20. In view of this, necessary revamps as well as installation of new units have been envisaged in the proposed quality improvement projects.

Under Quality Improvement Project, revamp of its existing DHDS, Prime-G and HGU-1 units apart from the addition of new CCR and ISOM units are proposed to improve the quality of products produced from these units which shall in result enable Refinery to meet stringent specifications of BS-VI MS & HSD as per the Government of India guidelines.

However, as per the specification of BS-VI received from Centre of High Technology (CHT), total sulphur content in HSD pool shall be 10 ppmw. Hence, in order to produce BS-VI HSD from Mathura Refinery considerable reduction in the sulphur content of diesel stream of DHDS unit from 50 ppmw to 10 ppmw would be required.

In order to convert excess Naphtha currently produced from Mathura Refinery into valuable MS blending component, new CCR and ISOM units have been proposed under QIP. These proposed CCR and ISOM units shall produced the MS blending component of sulphur content less than 10 ppmw which is in line with the available BS-VI specifications.

7. ENVIRONMENTAL MONITORING PROGRAM

7.1. Preamble

An Environmental Monitoring Plan provides feedback about the difference between existing environmental scenario and the impacts due to project on the environment and helps to judge the adequacy of the mitigation measures in protecting the environment. The purpose of environmental monitoring is to evaluate the effectiveness of implementation of Environmental Management Plan (EMP) by periodically monitoring the important environmental parameters within the impact area, so that any adverse effects are detected and timely action can be taken.

Regular monitoring of environmental parameters is of immense importance to assess the status of environment during operation. With the knowledge of baseline conditions, the monitoring program will serve as an indicator for any deterioration in environmental conditions due to operation of the project, to enable taking up suitable mitigation steps in time to safeguard the environment. Monitoring is as important as that of control of pollution since the efficiency of control measures can be determined only by efficient monitoring.

7.2. Objectives of Environmental Monitoring Plan

The basic objective of Environment Monitoring Program is:

- To ensure implementation of mitigation measures during project implementation
- To provide feedback to the decision makers about the effectiveness of their actions
- To determine the project's actual environmental impacts so that modifications can be made to mitigate the impacts
- To identify the need for enforcement action before irreversible environmental damage occurs
- To provide scientific information about the response of an ecosystem to a given set of human activities and mitigation measures

7.3. Environmental Monitoring and Reporting Procedure

Monitoring shall ensure that commitments are being met. This may take the form of direct measurement and recording quantitative information, such as concentrations of discharge, emissions and wastes, for measurement against corporate or statutory standards, consent limits or targets. It may also require measurement of ambient environmental quality in the vicinity of a site using ecological/biological, physical and chemical indicators. Monitoring may include socio-economic interaction, through local liaison activities or even assessment of complaints.

7.4. Environmental Monitoring Program

Being a well established facility, the existing facility has implemented a robust environmental monitoring program and the same will be implemented after the proposed quality improvement program. Summary of the existing and proposed environmental monitoring programs are presented in Table 7.1.

Table 7-1 Environmental Monitoring Program

S.No	Aspect	Existing monitoring program	Additional Monitoring Program Suggested
1	Environmental management systems	The existing facility is accredited for ISO 14001 environmental management systems and OSHA 18001 occupational health and safety systems. Periodical reviews by the Environment and safety committees and the plant head is being undertaken for continual improvement.	The existing systems will be continued. Recommendations of risk assessment will be included in the existing environmental manuals.
2	Online emission monitoring systems	Online emission monitoring systems for measuring SO_2, NO_x, CO, PM are installed in all 27 stacks. Online analyzers are considered for monitoring emissions as per existing air environment management system. In addition, mobile van monitoring system along with baseline data stations at various locations in 10 kms radius of refinery are already working by Mathura refinery to check daily monitoring values for SO2. The standards monitoring program in form of LDAR VOC monitoring as per guidelines given in environmental standard for refineries as per Gazette Notification dated 18th March 2008 are being monitored.	Online emission monitoring system for the proposed stack will be installed as per CPCB guide lines.

S.No	Aspect	Existing monitoring program	Additional Monitoring Program Suggested
3	Emission monitoring by external laboratory	Emission tests are being undertaken by MoEF/NABL accredited laboratory on monthly basis on the various stacks.	Similar practices will be undertaken during the post project scenario in consultation with PCB.
4	Continuous Ambient air quality monitoring	Four continuous ambient air quality monitoring stations were installed as per the CPCB guidelines. In particular, three ambient air quality-monitoring stations between the refinery and the city of Agra and a fourth one at Bharatpur and relevant parameters such as PM, SO_2, NO_x, CO are being monitored on continuous basis.	The existing systems will be continued.
5	Ambient air quality monitoring by external lab	Ambient air quality is monitored at outside the facility by an MoEF & CC/NABL accredited testing agency as per the CPCB guidelines. Monitoring is undertaken twice a week and the monthly reports are submitted to PCB.	Similar practices will be undertaken during the post project scenario in consultation with PCB.
6	Treated wastewater quantity monitoring	Online wastewater flow meters are installed on the following areas: inlet to the ETP, treated wastewater recycled in the plant and treated unutilized excess wastewater discharged into river.	The existing systems will be continued.
7	Continuous monitoring of treated wastewater quality	On line pH indicator, BOD, COD, TSS, and oil is installed to the final discharge channel connected to drain.	The existing systems will be continued.
8	Treated wastewater quality monitoring by external lab	Treated wastewater quality samples are analysed by Refinery in house laboratory on daily basis. An MoEF/NABL accredited lab is also undertaking sampling and analysis of treated wastewater on monthly basis for the parameters such as pH, TSS, BOD, COD, TDS, etc	Existing practices will be continued.
9	Noise recording	Noise levels at work zones are being monitored on monthly basis as a part of the occupational health surveillance program by Mathura refinery in-house team.	Existing practices will be continued.
10	Solid waste generation and disposal	Hazardous wastes such as used oil, sludge, spent catalyst are being recorded as per the Hazardous Waste Authorization issued by PCB.	Similar practices will be undertaken during the post project scenario in consultation with PCB.

7.5. Data Analysis

The monitored data will be analyzed and compared with the baseline levels as established in the EIA study and the regulatory standards specified by different

government agencies. The standards against which the different environment components will be compared are as per Table 7.2.

Table 7-2 Recommended Environmental Monitoring Plan

S.No	Component	Applicable Standards
1	Ambient Air Quality	National Ambient Air Quality Standards (NAAQS), Central Pollution Control Board, State Pollution Control Board (SPCB)
2	Noise Quality	Ambient Air Quality Standards with respect to Noise, CPCB
3	Surface Water Quality	IS:2296: Class 'C' Water, CPCB
4	Groundwater Quality	IS: 10500 Standards, BIS
5	Soil Quality	--
6	Treated wastewater	IS 2490 (1974) – Discharge into Sea, IS 3306(1974) – Discharge on land, IS 3307(1974) - Discharge for agricultural use State Pollution Control Board (SPCB)

7.6. Reporting Schedule

The monitoring results of the different environmental components will be analyzed and compiled report will be sent to concerned authorities every six months. pH, BOD, COD, TSS, Oil, Air quality parameters like PM_{10}, $PM_{2.5}$, SO_2, NO_x, VOC will be online and logged on to SPCB / CPCB web portals. The report will also list the project activities along with the environmental mitigation measures and will evaluate the efficiency of the Environmental Management Plan.

8. ADDITIONAL STUDIES

This chapter describes the risk assessment and disaster management plan, Fire Safety Systems and Occupational Health and Safety of the plant.

8.1. Public Consultation

As per the Terms of Reference issued by MoEF&CC vide Letter No.J-11011/151/2016-IA II (I) dated 23rd September 2016, the public hearing for the proposed quality improvement project is exempted.

8.2. Rapid Risk Assessment Study and Risk Mitigation Measures

According to the specific items 18 and 7(Xiii) of the Terms of Reference (ToR) issued for the project, preliminary hazard identification and risk assessment was undertaken to quantify the possible fire and occupational health risks associated with the operation of the project at the designated location. The good engineering practices suggested by the Central Pollution Control Board for risk assessment in industries (CPCB document Probes/133/ 2009-10) and CPR-18E risk assessment procedures' guidelines which are widely accepted by the Ministry of Environment and Forests (MoEF) India, have been adopted while assessing the residual risks associated with the operations of the project with specific reference to fire hazards, chemical exposure hazards, occupational hazards and natural hazards.

Based on the findings of the risk assessment study, a preliminary risk management plan has been developed as per the applicable rules and guidelines; wherever possible, good engineering and management practices are suggested to minimise any intolerable risks.

8.2.1. Scope of the Study

Scope of the RRA study covers the following:

- New HDS reactor inclusion in DHDS
- Second stage Amine absorber in FCC Gasoline Desulphurisation
- CCRU unit
- Isomerisation unit

8.2.2. Objective of the Study

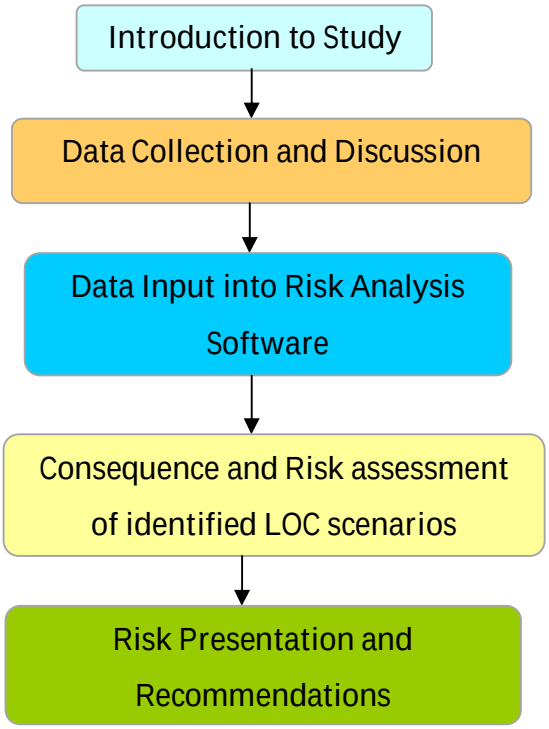
The Objective of RRA study is

- Identification of worst case accidental events
- Assessment of risk arising from the hazards and consideration of its tolerability to personnel, refinery and the environment which includes the following
  - Calculation of physical effects of accidental scenarios.
  - Identification and quantification of the risks and contour mapping on the layouts.
  - Evaluation of risk against the risk acceptable limits.
  - Risk reduction measures to prevent incidents, to control accidents.

8.2.3. Methodology Adopted

The risk assessment calculations based on the shared data was carried out at using DNV's PHAST Risk V6.7 software. Finally, risk reduction measures were suggested based on the risk levels.

The above-adopted methodology is depicted in the form of flow chart below:



8.2.4. Risk Assessment Procedure

Hazard identification and risk assessment involves a series of steps as follows:

Step 1: Identification of the Hazard

Hazard identification is a critical step in Risk Assessment. Many aids are available,

including experience, engineering codes, checklists, detailed process knowledge, equipment failure experience, hazard index techniques, What-if Analysis, Hazard and Operability (HAZOP) Studies, Failure Mode and Effects Analysis (FMEA), and Preliminary Hazard Analysis (PHA). In this phase, all potential incidents are identified and tabulated. Site visit and study of operations and documents like drawings, process write-up etc are used for hazard identification.

Step 2: Assessment of the Risk

Consequence estimation is the methodology used to determine the potential for damage or injury from specific incidents. A single incident (e.g. rupture of a pressurized flammable liquid tank) can have many distinct incident outcomes (E.g. Unconfined Vapor Cloud Explosion (UVCE), Boiling Liquid Expanding Vapor Explosion (BLEVE), flash fire, etc.)

Likelihood assessment is the methodology used to estimate the frequency or probability of occurrence of an incident. Estimates may be obtained from historical incident data on failure frequencies, from failure sequence models, such as fault trees and event trees or both. In this study the historical data developed by software models and those collected by CPR18E – Committee for Prevention of Disasters, Netherlands (Edition: PGS 3, 2005) are used.

Risks arising from the hazards are evaluated for its tolerability to personnel, the refinery and the environment. The acceptability of the estimated risk must then be judged based on IS-15656 criteria appropriate to the particular situation.

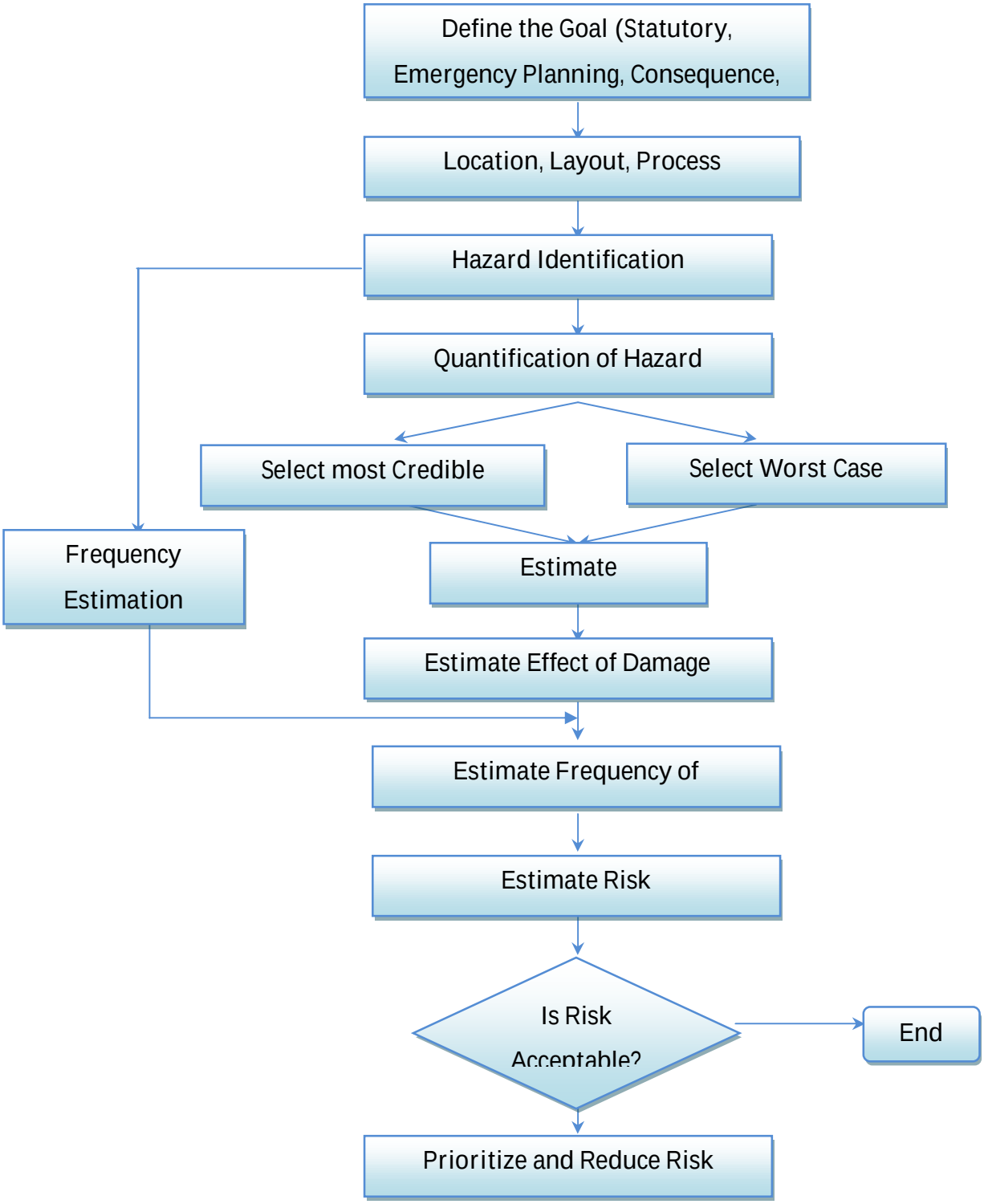
Step 3: Elimination or Reduction of the Risk

This involves identifying opportunities to reduce the likelihood and/or consequence of an accident Where deemed to be necessary. Risk assessment combines the consequences and likelihood of all incident outcomes from all selected incidents to provide a measure of risk. The risk of all selected incidents are individually estimated and summed to give an overall measure of risk. Risk-reduction measures include those to prevent incidents (i.e. reduce the likelihood of occurrence) to control incidents (i.e. limit the extent and duration of a hazardous event) and to mitigate the effects (i.e. reduce the consequences). Preventive measures, such as using inherently safer designs and ensuring asset integrity, should be used wherever practicable.

In many cases, the measures to control and mitigate hazards and risks are simple and obvious and involve modifications to conform to standard practice. The general hierarchy of risk reducing measures is:

- Prevention (by distance or design);
- Detection (E.g. fire and gas, Leak detection);
- Control (E.g. emergency shutdown and controlled depressurization);
- Mitigation (E.g. fire fighting and passive fire protection);
- Emergency response (In case safety barriers fail).

8.2.5. QRA Methodology



8.2.6. Identification of Hazards and Release Scenarios

Containment is defined as one or several devices; any parts which are permanently in open contact with one another, and which are intended to contain one or multiple substances. A Loss of Containment is one containment system that will not lead to the release of significant quantities of hazardous substance from other containment systems.

The following data were collected to envisage scenarios:

- Composition of materials flowing through equipments and pipeline;
- Flow rate of materials passing through pipelines;
- Equipment/pipeline conditions (phase, temperature, pressure);

Accidental release of flammable liquids/gases can result in severe consequences. Delayed ignition of flammable gases can result in blast overpressures covering large areas. This may lead to extensive loss of life and property. In contrast, fires have localized consequences. Fires can be put out or contained in most cases; there are few mitigating actions one can take once a flammable gas or a vapor cloud gets released. Major accident hazards arise, therefore, consequent upon the release of flammable gases.

8.2.7. Factors for Identification of Hazards

In any installation, main hazard arises due to loss of containment during handling of flammable chemicals. To formulate a structured approach to identification of hazards, an understanding of contributory factors is essential.

Inventory

Inventory analysis is commonly used in understanding the relative hazards and short listing of release scenarios. Inventory plays an important role in regard to the potential hazard. Larger the inventory of a vessel or a system, larger is the quantity of potential release. A practice commonly used to generate an incident list is to consider potential leaks and major releases from fractures of pipelines and vessels/tanks containing sizable inventories.

Parameters

Potential vapor release for the same material depends significantly on the operating conditions. This operating range is enough to release a large amount of vapor in case of a leak/rupture, therefore the storage tank/pipeline leaks and ruptures need to be considered in the risk Assessment calculations.

Blast overpressures depend upon the reactivity class of material and the amount of gas between two explosive limits. For example, LPG once released and not ignited immediately is expected to give rise to a vapor cloud. These vapors in general have medium reactivity and in case of confinement of the gas cloud, on delayed ignition may result in an explosion and overpressures.

Initiating Events

Both the complexity of study and the number of incident outcome cases are affected by the range of initiating events and incidents covered. This not only reflects the inclusion of accidents and/or non-accident-initiated events, but also the size of those events.

In this study, two types of LOC events are envisaged viz., the one in which there is a high frequency of occurrence but having low consequential effects (hole in the drain/vent line of the reactor, instrument tapping failure, etc.,) and the one in which there is a low frequency of occurrence but with high consequential effects (a catastrophic rupture of a vessel).

8.2.8. Consequence Calculations

In consequence, analysis, use is made of a number of calculation models to estimate the physical effects of an accident (spill of hazardous material) and to predict the damage (lethality, injury, material destruction) of the effects.

Accidental release of flammable liquids can result in severe consequences. Immediate ignition of the pressurized chemical will result in a jet flame. Delayed ignition of flammable vapors can result in blast overpressures covering large areas.

The calculations can roughly be divided in three major groups:

a) Determination of the source strength parameters;
b) Determination of the consequential effects;
c) Determination of the damage or damage distances.

Source Strength Parameters

- Calculation of the outflow of liquid vapors out of a vessel/tank or a pipe, in case of rupture. In addition, two-phase outflow can be calculated.
- Calculation, in case of liquid outflow, of the instantaneous flash evaporation and of the dimensions of the remaining liquid pool.
- Calculation of the evaporation rate, as a function of volatility of the material, pool dimensions and wind velocity.
- Source strength equals pump capacities, etc. in some cases.

Consequential Effects

- Dispersion of gaseous material in the atmosphere as a function of source strength, relative density of the gas, weather conditions and topographical situation of the surrounding area.
- Intensity of heat radiation [in kW/ m2] due to a fire, as a function of the distance to the source.
- Energy of vapor cloud explosions [in bar], as a function of the distance to the distance of the exploding cloud.
- Concentration of gaseous material in the atmosphere, due to the dispersion of evaporated chemical. The latter can be either explosive or toxic.

8.2.9. Selection of Damage Criteria

The damage criteria give the relation between the extents of the physical effects (exposure) and the effect of consequences. For assessing, the effects on human beings consequences are expressed in terms of injuries and the effects on equipment / property in terms of monetary loss. The effect of consequences for explosion or fire can be categorized as:

- Damage caused by heat radiation on material and people
- Damage caused by explosion on structure and people

In consequence, analysis studies, in principle three types of exposure to hazardous effects are distinguished:

- Heat radiation due to fires - in this study, the concern is that of Jet fires and pool fires
- Explosions
- Toxic effects, from toxic materials.

The knowledge about these relations depends strongly on the nature of the exposure. Following are the criteria selected for damage estimation:

Heat Radiation

The effect of fire on a human being is in the form of burns. There are three categories of burn such as first degree, second degree and third degree burns. The consequences caused by exposure to heat radiation are a function of:

- The radiation energy onto the human body [kW/m^2];
- The exposure duration [sec];
- The protection of the skin tissue (clothed or naked body).

The limits for 1% of the exposed people to be killed due to heat radiation, and for second-degree burns are given in the table below:

Table 8-1 Damages to Human life due to Heat Radiation

Exposure Duration	Radiation energy (1% lethality), kW/m^2	Radiation energy (2nd degree burns), kW/m^2	Radiation energy (1st degree burns), kW/m^2
10 sec	21.2	16	12.5
20 sec	9.3	7.0	4.0

Table 8-2 Effects due to Incident Radiation Intensity

Incident Radiation (kW/m^2)	Type of Damage
0.7	Equivalent to Solar Radiation
4.0	Sufficient to cause pain within 20 sec. Blistering of skin (first degree burns are likely)
12.5	Minimum energy required for piloted ignition of wood, melting plastic tubing etc.
37.5	Heavy Damage to process equipments

Reference: CCPS, Guidelines for Chemical Process Quantitative Risk Analysis

The actual results would be less severe due to the various assumptions made in the models arising out of the flame geometry, emissivity, angle of incidence, view factor and

others. The radiation output of the flame would be dependent upon the fire size, extent of mixing with air and the flame temperature.

As per the guidelines of CPR 18 E Purple Book:

- The lethality of a jet fire and pool fire is assumed to be 100% for the people who are caught in the flame. Outside the flame area, the lethality depends on the heat radiation distances.
- For the flash fires lethality is taken as 100% for all the people caught outdoors and for 10% who are indoors within the flammable cloud. No fatality has been assumed outside the flash fire area.
- Overpressure more than 0.3 bar corresponds approximately with 50% lethality.
- An overpressure above 0.2 bar would result in 10% fatalities.
- An overpressure less than 0.1 bar would not cause any fatalities to the public.
- 100% lethality is assumed for all people who are present within the cloud proper.

Table 8-3 Damage due to overpressures

Peak Overpressure	Damage Type	Description
0.30 bar	Heavy Damage	Major damage to plant equipment structure
0.10 bar	Moderate Damage	Repairable damage to plant equipment and structure
0.03 bar	Significant Damage	Shattering of glass

8.2.10. Probabilities

Population Probabilities

It is necessary to know the population exposure in order to estimate the consequences and the risk resulting from an incident. The exposed population is often defined using a population density. Population densities are an important part of a Risk assessment for several reasons. The most notable is that the density is typically used to determine the number of people affected by a given incident with a specific hazard area. The population density can be averaged over the whole area that may be affected or the area can be subdivided into any number of segments with a separate population density for each individual segment.

In this study, based on the data from IOCL, the following population data were considered for the study.

Table 8-4 Population Distribution

S. No	Location	Population
1	Admin building + project building	269
2	Stores	11
3	Laboratory	36
4	Time Office	10
5	First Aid	2
6	FCCU C/R	131
7	New& old SRU Control Room	84
8	New Unit (OHCU/DHDS/ HGU) Control Room	108
9	OM&S-I	169
10	LPG Control Room Building	47
11	LPG bulk truck loading gantry	
12	ETP	
13	BITUMEN P/H	
14	Water block	73
15	TPS	103
16	Fire & Safety	27
17	RSM building	16
18	W/Shop	134
19	CISF barrack Near Refinery	119
20	Total contract labours	2604
21	CISF at Gate and watch towers inside refinery	45

Failure / Accident Probabilities

The failure data is taken from CPR 18E – Guidelines for Quantitative Risk Assessment, developed by the Committee for the Prevention of Disasters, Netherlands.

The impacts due to internal domino effects are not explicitly covered in QRA. An internal domino needs to be considered only in case of a situation in which the failure of one component clearly leads to the failure of another component. As the biggest vessel/ tank are considered for instantaneous failure the impact due to internal domino effects are assumed to get covered in the analysis.

Weather Probabilities

As per CPR 18E there are 6 representative weather classes:

Stability Class	Wind Speed
B	Medium
D	Low

Stability Class	Wind Speed
D	Medium
D	High
E	Medium
F	Low

* *Low wind speed corresponds with 1-2 m/s*
* *Medium wind speed corresponds with 3-5 m/s*
* *High wind speed corresponds with 8-9 m/s*

Observations in the Pasquill stability classes C, C/D and D are allocated to stability class D. Wind speeds below 2.5 m/s, between 2.5 m/s and 6 m/s and above 6 m/s are allocated to the wind speed categories low, medium and high respectively.

Wind Speed	A	B	B/C	C	C/D	D	E	F
<2.5 m s^{-1}	B Medium			D Low			F Low	
2.5-6 m s^{-1}				D Medium			E Medium	
>6 m s^{-1}				D high				

The wind speed in each weather class is equal to the average wind speed of the observations in the weather class.

For this study, as per the standard meteorological data available for the site, wind velocity on a maximum throughout a year is 1 m/s. Based on the meteorological data, following weather conditions are considered:

- 1 F (Where F denotes Stable Condition – night with moderate clouds and light moderate winds; 1 denotes wind velocity in m /sec)
- 2 D (where D denotes neutral condition – little sun and high wind or over cast / windy night; 2 denotes wind velocity in m /sec)

In general the largest effect distance for release of substances is found with stable weather.

Temperature and Relative Humidity

Based on Climatologically data from the Indian Meteorological Department, an average temperature of 28°C and relative humidity of 56% is found pre-dominant in the facility.

Scenarios

This section documents the consequence-distance calculations, which have been computed for the accident release scenarios considered. Following are the potential

Loss of Containment scenarios envisaged for IOCL refinery.

Table 8-5 LOC scenarios identified for the study

S.No	Scenarios
Diesel Hydrodesulphurisation (Revamp)	
1	Leak of R-101 (Third HDS reactor)
2	Rupture of R-101 (Third HDS reactor)
Gasoline Hydrodesulphurisation (Revamp)	
3	Leak of 307-C-101 (N) (Second stage amine absorber)
4	Rupture of 307-C-101 (N) (Second stage amine absorber)
CCRU	
5	Leak of 014-R-1 (Hydrotreater reactor)
6	Rupture of 014-R-1 (Hydrotreater reactor)
7	Leak of 015-R-3 (Third Reforming reactor)-Reactor section
8	Rupture of 015-R-3 (Third Reforming reactor)-Reactor section
9	Leak of 015-P-3 (A/B) (Stabilizer Feed pumps)-Fractionation section
10	Rupture of 015-P-3 (A/B) (Stabilizer Feed pumps)-Fractionation section
Isomerisation	
11	Leak of 2112-C-01 (Naphtha Splitter-1)
12	Rupture of 2112-C-01 (Naphtha Splitter-1)
13	Leak of 2112-C-03 (FCC Heart cut Naphtha Splitter)
14	Rupture of 2112-C-03 (FCC Heart cut Naphtha Splitter)
15	Leak of 2112-C-04 (NHT Stripper)
16	Rupture of 2112-C-04 (NHT Stripper)
17	Leak of 2112-K-02 (A/B) (NHT Make up gas compressor)
18	Rupture of 2112-K-02 (A/B) (NHT Make up gas compressor)
19	Leak of 2113-R-02 (A/B) (PENEX reactor)
20	Rupture of 2113-R-02 (A/B) (PENEX reactor)

Table 8-6: Wind Direction

	Percentage number of days wind from								
	N	NE	E	SE	S	SW	W	NW	Calm
Night	3	9	7	10	3	10	11	23	24
Day	4	10	5	9	2	8	10	29	23

Ignition Probabilities

Immediate Ignition Probability:

Immediate ignition can be considered as the situation where the fluid ignites immediately on release through auto-ignition or because the accident which causes the release also provided an ignition source. Immediate ignition probability is assumed based on the Reference manual BEVI risk assessments version 3.2, developed by the National Institute of Public Health and the Environment (RIVM), Centre for External Safety, Netherlands.

Table 8-7 Probability of Immediate Ignition

Substance category	Source term Continuous	Source term Instantaneous	Probability of direct ignition
Category **0** (average/ high reactivity gases)	< 10 kg/s	< 1,000 kg	0.2
	10 – 100 kg/s	1000 – 10,000 kg	0.5
	> 100 kg/s	> 10,000 kg	0.7
Category **0** (low reactivity gases)	< 10 kg/s	< 1,000 kg	0.02
	10 – 100 kg/s	1000 – 10,000 kg	0.04
	> 100 kg/s	> 10,000 kg	0.09
Category 1 (highly flammable liquids)	All flow rates	All quantities	0.065
Category 2 (flammable liquids)	All flow rates	All quantities	0.01

Delayed Ignition Probability:

Delayed ignition is the result of the build-up of a flammable vapour cloud which is ignited by a source remote from the release point. It is assumed to result in flash fires or explosions, and also to burn back to the source of the leak resulting in a jet fire and/or a pool fire. Delayed ignition probability is assumed based on the National Institute of Public Health and the Environment (RIVM), Centre for External Safety, Netherlands.

Table 8-8 Probability of Delayed Ignition

Source Type	Ignition Source	Probability of Ignition
Point source	Adjacent process installation Flare Oven (outside) Oven (inside) Boiler (outside) Boiler (inside)	0.5 1.0 0.9 0.45 0.45 0.23
Line source	high-voltage cable (per 100 m) Ship	0.2 0.5
Population source	Households (per person) Offices (per person)	0.01 0.01

Modeling Assumptions

In addition to the methods and assumptions in the modeling as noted above, the following assumptions are used:

- For the PHAST modeling the 'horizontal' option is selected for release orientation, this provides the maximum horizontal distances.
- Jet fires in PHAST have been modeled using the un-impinged jet model. This leads to conservative, longer jet fire lengths as the model assumes that there are

no obstacles to reduce jet momentum and therefore jet length and distances to radiation levels.

- Isolation time (includes time for detection & isolation) of 10 minutes is considered for the released inventory calculations.
- The probability of failure on demand of the system as a whole is about 0.01 per demand.
- TNT explosion model is used in the study.
- Probability of Flash fire is 0.6 and Explosion is 0.4

8.2.11. Scenarios

This section documents the consequence-distance calculations, which have been computed for the accident release scenarios considered. Following are the potential Loss of Containment scenarios envisaged for IOCL refinery.

Table 8-9 LOC scenarios identified for the study

S.No	Scenarios
Diesel Hydrodesulphurisation (Revamp)	
1	Leak of R-101 (Third HDS reactor)
2	Rupture of R-101 (Third HDS reactor)
Gasoline Hydrodesulphurisation (Revamp)	
3	Leak of 307-C-101 (N) (Second stage amine absorber)
4	Rupture of 307-C-101 (N) (Second stage amine absorber)
CCRU	
5	Leak of 014-R-1 (Hydrotreater reactor)
6	Rupture of 014-R-1 (Hydrotreater reactor)
7	Leak of 015-R-3 (Third Reforming reactor)-Reactor section
8	Rupture of 015-R-3 (Third Reforming reactor)-Reactor section
9	Leak of 015-P-3 (A/B) (Stabilizer Feed pumps)-Fractionation section
10	Rupture of 015-P-3 (A/B) (Stabilizer Feed pumps)-Fractionation section
Isomerisation	
11	Leak of 2112-C-01 (Naphtha Splitter-1)
12	Rupture of 2112-C-01 (Naphtha Splitter-1)
13	Leak of 2112-C-03 (FCC Heart cut Naphtha Splitter)
14	Rupture of 2112-C-03 (FCC Heart cut Naphtha Splitter)
15	Leak of 2112-C-04 (NHT Stripper)
16	Rupture of 2112-C-04 (NHT Stripper)
17	Leak of 2112-K-02 (A/B) (NHT Make up gas compressor)
18	Rupture of 2112-K-02 (A/B) (NHT Make up gas compressor)
19	Leak of 2113-R-02 (A/B) (PENEX reactor)
20	Rupture of 2113-R-02 (A/B) (PENEX reactor)

8.2.12. Consequence Analysis

Sudden release of hydrocarbon can result in a number of accident situations. As large number of failure cases can lead to the same type of consequences, representative failure cases are selected for this analysis. The failure cases are based on conservative assumptions and engineering judgment. Typically, failure models are considered for 100% pipe diameter/catastrophic rupture of vessels for rupture and 10% leak (hole size max 50 mm) for pipelines and 10mm leak size for vessels, based on the guidelines of CPR 18 E.

Table 8-10 Parameters

S.No	Scenarios	Flow rate (Kg/hr)	Pressure bar (G)	Temperature (°C)
Diesel Hydrodesulphurisation (Revamp)				
1	Leak of R-101 (Third HDS reactor)	104760.67	38.5	392
2	Rupture of R-101 (Third HDS reactor)	104760.67	38.5	392
Gasoline Hydrodesulphurisation (Revamp)				
3	Leak of 307-C-101 (N) (Second stage amine absorber)	4914.00	14.7	45
4	Rupture of 307-C-101 (N) (Second stage amine absorber)	4914.00	14.7	45
CCRU				
5	Leak of 014-R-1 (Hydrotreater reactor)	72459.00	20.5	340
6	Rupture of 014-R-1 (Hydrotreater reactor)	72459.00	20.5	340
7	Leak of 015-R-3 (Third Reforming reactor)-Reactor section	92811.00	3.5	540
8	Rupture of 015-R-3 (Third Reforming reactor)-Reactor section	92811.00	3.5	540
9	Leak of 015-P-3 (A/B) (Stabilizer Feed pumps)-Fractionation section	70768.00	21.8	33
10	Rupture of 015-P-3 (A/B) (Stabilizer Feed pumps)-Fractionation section	70768.00	21.8	33
Isomerisation				
11	Leak of 2112-C-01 (Naphtha Splitter-1)	40200.00	7.1	123
12	Rupture of 2112-C-01 (Naphtha Splitter-1)	40200.00	7.1	123
13	Leak of 2112-C-03 (FCC Heart cut Naphtha Splitter)	20000.00	2.1	61
14	Rupture of 2112-C-03 (FCC Heart cut Naphtha Splitter)	20000.00	2.1	61
15	Leak of 2112-C-04 (NHT Stripper)	29002.00	12.5	130
16	Rupture of 2112-C-04 (NHT Stripper)	29002.00	12.5	130
17	Leak of 2112-K-02 (A/B) (NHT Make up gas compressor)	482.00	32.1	95
18	Rupture of 2112-K-02 (A/B) (NHT Make up gas compressor)	482.00	32.1	95
19	Leak of 2113-R-02 (A/B) (PENEX reactor)	47890.00	31.79	202
20	Rupture of 2113-R-02 (A/B) (PENEX reactor)	47890.00	31.79	202

Summary of Jet Fire

Table 8-11Jet fire results

S.No	Scenarios	Jet fire radiation downwind damage distances in m					
		1 F Weather Condition			2 D Weather condition		
		4	12.5	37.5	4	12.5	37.5
		kW/m²			kW/m²		
Diesel Hydrodesulphurisation (Revamp)							
1	Leak of R-101 (Third HDS reactor)	53.85	41.60	32.54	53.91	42.09	33.17
2	Rupture of R-101 (Third HDS reactor)	NA	NA	NA	NA	NA	NA
Gasoline Hydrodesulphurisation (Revamp)							
3	Leak of 307-C-101 (N) (Second stage amine absorber)	12.73	9.62	NR	12.86	9.86	NR
4	Rupture of 307-C-101 (N) (Second stage amine absorber)	NA	NA	NA	NA	NA	NA
CCRU							
5	Leak of 014-R-1 (Hydrotreater reactor)	46.22	36.06	28.42	46.24	36.42	28.91
6	Rupture of 014-R-1 (Hydrotreater reactor)	NA	NA	NA	NA	NA	NA
7	Leak of 015-R-3 (Third Reforming reactor)-Reactor section	15.35	12.22	NR	15.32	12.27	NR
8	Rupture of 015-R-3 (Third Reforming reactor)-Reactor section	NA	NA	NA	NA	NA	NA
9	Leak of 015-P-3 (A/B) (Stabilizer Feed pumps)-Fractionation section	82.17	64.65	54.24	78.31	60.09	49.32
10	Rupture of 015-P-3 (A/B) (Stabilizer Feed pumps)-Fractionation section	NA	NA	NA	NA	NA	NA
Isomerisation							
11	Leak of 2112-C-01 (Naphtha Splitter-1)	134.02	105.51	88.66	127.17	97.80	80.56
12	Rupture of 2112-C-01 (Naphtha Splitter-1)	NA	NA	NA	NA	NA	NA
13	Leak of 2112-C-03 (FCC Heart cut Naphtha Splitter)	126.86	99.92	83.36	120.25	92.47	75.58
14	Rupture of 2112-C-03 (FCC Heart cut Naphtha Splitter)	NA	NA	NA	NA	NA	NA
15	Leak of 2112-C-04 (NHT Stripper)	52.37	38.67	29.16	52.58	39.73	30.49
16	Rupture of 2112-C-04 (NHT Stripper)	NA	NA	NA	NA	NA	NA
17	Leak of 2112-K-02 (A/B) (NHT Make up gas compressor)	19.24	13.99	NR	19.60	14.62	NR
18	Rupture of 2112-K-02 (A/B) (NHT Make up gas compressor)	NA	NA	NA	NA	NA	NA
19	Leak of 2113-R-02 (A/B) (PENEX reactor)	73.33	54.27	41.22	73.49	55.36	42.49
20	Rupture of 2113-R-02 (A/B) (PENEX reactor)	NA	NA	NA	NA	NA	NA

Analysis:

Isomerisation: Leak of 2112-C-01 (Naphtha Splitter-1), at a weather condition of 1 F, will cause maximum damage due to jet fire. The jet fire radiation of 4 kW/m² will reach up to a distance of 134.02m, 12.5 kW/m² will reach up to a distance of 105.51m and 37.5 kW/m² will reach up to a distance of 88.66m.

Summary Of Late Pool Fire

Table 8-12 Pool fire results

S.No	Scenarios	Pool fire radiation downwind damage distances in **m**					
		1 F Weather Condition			**2 D** Weather condition		
		4	12.5	37.5	4	12.5	37.5
		kW/m²			kW/m²		
Diesel Hydrodesulphurisation (Revamp)							
1	Leak of R-101 (Third HDS reactor)	NA	NA	NA	NA	NA	NA
2	Rupture of R-101 (Third HDS reactor)	NA	NA	NA	NA	NA	NA
Gasoline Hydrodesulphurisation (Revamp)							
3	Leak of 307-C-101 (N) (Second stage amine absorber)	NA	NA	NA	NA	NA	NA
4	Rupture of 307-C-101 (N) (Second stage amine absorber)	NA	NA	NA	NA	NA	NA
CCRU							
5	Leak of 014-R-1 (Hydrotreater reactor)	NA	NA	NA	NA	NA	NA
6	Rupture of 014-R-1 (Hydrotreater reactor)	NA	NA	NA	NA	NA	NA
7	Leak of 015-R-3 (Third Reforming reactor)-Reactor section	NA	NA	NA	NA	NA	NA
8	Rupture of 015-R-3 (Third Reforming reactor)-Reactor section	NA	NA	NA	NA	NA	NA
9	Leak of 015-P-3 (A/B) (Stabilizer Feed pumps)-Fractionation section	43.92	31.91	24.34	38.61	32.20	25.72
10	Rupture of 015-P-3 (A/B) (Stabilizer Feed pumps)-Fractionation section	65.16	29.01	NR	74.84	28.51	NR
Isomerisation							
11	Leak of 2112-C-01 (Naphtha Splitter-1)	NR	NR	NR	NR	NR	NR
12	Rupture of 2112-C-01 (Naphtha Splitter-1)	NR	NR	NR	NR	NR	NR
13	Leak of 2112-C-03 (FCC Heart cut Naphtha Splitter)	75.73	39.97	NR	82.34	38.34	NR
14	Rupture of 2112-C-03 (FCC Heart cut Naphtha Splitter)	91.02	44.77	NR	104.12	45.75	NR
15	Leak of 2112-C-04 (NHT Stripper)	NA	NA	NA	NA	NA	NA
16	Rupture of 2112-C-04 (NHT Stripper)	NA	NA	NA	NA	NA	NA
17	Leak of 2112-K-02 (A/B) (NHT Make up gas compressor)	NA	NA	NA	NA	NA	NA
18	Rupture of 2112-K-02 (A/B) (NHT Make up gas compressor)	NA	NA	NA	NA	NA	NA
19	Leak of 2113-R-02 (A/B) (PENEX reactor)	NA	NA	NA	NA	NA	NA
20	Rupture of 2113-R-02 (A/B) (PENEX reactor)	NA	NA	NA	NA	NA	NA

Analysis:

Isomerisation: Rupture of 2112-C-03 (FCC Heart cut Naphtha Splitter), at a weather condition of 2 D, will cause maximum damage due to pool fire. The pool fire radiation of

4 kW/m² will reach up to a distance of 104.12m and 12.5 kW/m² will reach up to a distance of 45.75m.

Summary of Vapour Explosion

Table 8-13 Vapour cloud explosion results

S.No	Scenarios	Over Pressure Damage Distances in M					
		1 F Weather Condition			2 D Weather Condition		
		0.03	0.1	0.3	0.03	0.1	0.3
		bar			bar		
Diesel Hydrodesulphurisation (Revamp)							
1	Leak of R-101 (Third HDS reactor)	99.45	71.09	60.53	95.32	69.33	59.65
2	Rupture of R-101 (Third HDS reactor)	656.54	314.41	187.04	661.51	316.53	188.09
Gasoline Hydrodesulphurisation (Revamp)							
3	Leak of 307-C-101 (N) (Second stage amine absorber)	41.11	29.00	24.50	39.04	28.12	24.06
4	Rupture of 307-C-101 (N) (Second stage amine absorber)	276.95	135.14	82.59	279.16	136.26	83.06
CCRU							
5	Leak of 014-R-1 (Hydrotreater reactor)	87.80	66.12	58.05	84.62	64.77	57.37
6	Rupture of 014-R-1 (Hydrotreater reactor)	543.50	260.46	155.09	552.23	264.19	156.95
7	Leak of 015-R-3 (Third Reforming reactor)-Reactor section	23.52	15.76	12.88	22.58	15.36	12.68
8	Rupture of 015-R-3 (Third Reforming reactor)-Reactor section	639.40	307.10	183.39	635.71	305.53	182.60
9	Leak of 015-P-3 (A/B) (Stabilizer Feed pumps)-Fractionation section	360.16	279.78	249.85	249.87	192.59	171.27
10	Rupture of 015-P-3 (A/B) (Stabilizer Feed pumps)-Fractionation section	733.15	505.74	422.76	547.33	366.32	304.75
Isomerisation							
11	Leak of 2112-C-01 (Naphtha Splitter-1)	396.91	306.92	273.42	395.65	317.85	288.89
12	Rupture of 2112-C-01 (Naphtha Splitter-1)	1045.20	491.64	327.13	1046.80	498.06	377.09
13	Leak of 2112-C-03 (FCC Heart cut Naphtha Splitter)	602.79	394.72	317.26	335.27	234.75	197.33
14	Rupture of 2112-C-03 (FCC Heart cut Naphtha Splitter)	784.06	541.23	455.50	335.27	234.75	197.33
15	Leak of 2112-C-04 (NHT Stripper)	128.14	100.53	90.25	124.34	98.91	89.44
16	Rupture of 2112-C-04 (NHT Stripper)	491.26	232.45	136.10	497.47	235.10	137.42
17	Leak of 2112-K-02 (A/B) (NHT Make up gas compressor)	65.20	45.01	37.50	50.66	33.08	26.53
18	Rupture of 2112-K-02 (A/B) (NHT Make up gas compressor)	143.56	66.96	38.44	143.70	67.02	43.34
19	Leak of 2113-R-02 (A/B) (PENEX reactor)	174.72	137.60	123.78	159.12	125.21	112.59

S.No	Scenarios	Over Pressure Damage Distances in M					
		1 F Weather Condition			2 D Weather Condition		
		0.03	0.1	0.3	0.03	0.1	0.3
		bar			bar		
20	Rupture of 2113-R-02 (A/B) (PENEX reactor)	491.35	232.49	136.12	496.36	234.63	137.19

Analysis:

Isomerisation: Rupture of 2112-C-01 (Naphtha Splitter-1), at a weather condition of 2 D, will cause maximum damage due to vapour cloud explosion. An overpressure of 0.03 bar will reach up to a distance of 1046.80m, 0.1 bar will reach up to a distance of 496.06, 0.3 bar will reach up to a distance of 377.09m, at 2 D weather condition.

Summary of Flammable Gas Dispersion

Table 8-14: Flammable gas Dispersion Results

S.No	Scenarios	Distance to concentration results					
		1 F Weather Condition			2 D Weather condition		
		UFL	LFL	LFL Fraction	UFL	LFL	LFL Fraction
		m			m		
Diesel Hydrodesulphurisation (Revamp)							
1	Leak of R-101 (Third HDS reactor)	2.21	34.90	59.58	2.19	32.85	56.53
2	Rupture of R-101 (Third HDS reactor)	26.30	51.42	66.04	26.29	52.48	68.90
Gasoline Hydrodesulphurisation (Revamp)							
3	Leak of 307-C-101 (N) (Second stage amine absorber)	0.44	17.17	26.68	0.44	15.15	22.94
4	Rupture of 307-C-101 (N) (Second stage amine absorber)	6.80	27.18	36.69	6.79	29.23	41.69
CCRU							
5	Leak of 014-R-1 (Hydrotreater reactor)	2.26	26.46	54.90	2.24	24.75	52.28
6	Rupture of 014-R-1 (Hydrotreater reactor)	21.83	42.23	54.77	21.84	43.65	58.84
7	Leak of 015-R-3 (Third Reforming reactor)-Reactor section	0.67	9.25	19.01	0.67	8.40	16.92
8	Rupture of 015-R-3 (Third Reforming reactor)-Reactor section	29.31	53.86	69.84	29.31	55.57	75.92
9	Leak of 015-P-3 (A/B) (Stabilizer Feed pumps)-Fractionation section	24.46	101.71	227.00	9.84	91.17	157.53
10	Rupture of 015-P-3 (A/B) (Stabilizer Feed pumps)-Fractionation section	146.27	286.87	348.58	89.88	202.85	266.05
Isomerisation							
11	Leak of 2112-C-01 (Naphtha Splitter-1)	13.80	118.58	241.23	13.37	117.19	266.21
12	Rupture of 2112-C-01 (Naphtha	38.73	146.34	433.19	40.20	182.74	492.68

S.No	Scenarios	Distance to concentration results					
		1 F Weather Condition			**2 D** Weather condition		
		UFL	LFL	LFL Fraction	UFL	LFL	LFL Fraction
		m			m		
	Splitter-1)						
13	Leak of 2112-C-03 (FCC Heart cut Naphtha Splitter)	16.14	186.19	249.77	15.55	123.88	169.87
14	Rupture of 2112-C-03 (FCC Heart cut Naphtha Splitter)	68.02	292.87	376.96	71.73	216.71	280.61
15	Leak of 2112-C-04 (NHT Stripper)	4.16	35.63	86.51	4.10	33.62	83.15
16	Rupture of 2112-C-04 (NHT Stripper)	17.21	35.98	49.55	17.41	39.07	57.95
17	Leak of 2112-K-02 (A/B) (NHT Make up gas compressor)	0.38	23.69	31.41	0.37	19.43	26.97
18	Rupture of 2112-K-02 (A/B) (NHT Make up gas compressor)	2.79	14.82	19.54	2.79	15.77	21.78
19	Leak of 2113-R-02 (A/B) (PENEX reactor)	5.16	47.23	111.67	5.09	44.31	106.45
20	Rupture of 2113-R-02 (A/B) (PENEX reactor)	18.01	34.85	46.04	18.10	36.48	50.42

Analysis:

Isomerisation: In case of Rupture of 2112-C-01 (Naphtha Splitter-1), the UFL concentration is present up to a maximum downwind distance of 40.20m, LFL concentration is present up to a maximum downwind distance of 182.74m and LFL Fraction concentration is present up to a maximum distance of 492.68m at 2 D weather condition.

Summary of Toxic Dispersion

Table 8-15: Toxic Gas Dispersion Results

S.No	Scenarios	Toxic concentration in m	
		1 F Weather Condition	**2 D** Weather condition
		IDLH in ppm	IDLH in ppm
Diesel Hydrodesulphurisation (Revamp)			
1	Leak of R-101 (Third HDS reactor)	46.64	52.9
2	Rupture of R-101 (Third HDS reactor)	87.95	94.59
Gasoline Hydrodesulphurisation (Revamp)			
3	Leak of 307-C-101 (N) (Second stage amine absorber)	NR	NR
4	Rupture of 307-C-101 (N) (Second stage amine absorber)	8.03	8.02
CCRU			
5	Leak of 014-R-1 (Hydrotreater reactor)	NR	NR
6	Rupture of 014-R-1 (Hydrotreater	12.66	12.65

S.No	Scenarios	Toxic concentration in m	
		1 F Weather Condition	**2 D** Weather condition
		IDLH in ppm	IDLH in ppm
	reactor)		
7	Leak of 015-R-3 (Third Reforming reactor)-Reactor section	NR	NR
8	Rupture of 015-R-3 (Third Reforming reactor)-Reactor section	74.78	82.24
9	Leak of 015-P-3 (A/B) (Stabilizer Feed pumps)-Fractionation section	NA	NA
10	Rupture of 015-P-3 (A/B) (Stabilizer Feed pumps)-Fractionation section	NA	NA
Isomerisation			
11	Leak of 2112-C-01 (Naphtha Splitter-1)	77.93	81.99
12	Rupture of 2112-C-01 (Naphtha Splitter-1)	86.05	120.39
13	Leak of 2112-C-03 (FCC Heart cut Naphtha Splitter)	NA	NA
14	Rupture of 2112-C-03 (FCC Heart cut Naphtha Splitter)	NA	NA
15	Leak of 2112-C-04 (NHT Stripper)	NR	NR
16	Rupture of 2112-C-04 (NHT Stripper)	18.23	18.48
17	Leak of 2112-K-02 (A/B) (NHT Make up gas compressor)	NA	NA
18	Rupture of 2112-K-02 (A/B) (NHT Make up gas compressor)	NA	NA
19	Leak of 2113-R-02 (A/B) (PENEX reactor)	39.33	41.92
20	Rupture of 2113-R-02 (A/B) (PENEX reactor)	68.7	63.89

Analysis:

Isomerisation: In case of Rupture of 2112-C-01 (Naphtha Splitter-1), IDLH concentration is present to a maximum distance of 120.39m at 2 D weather condition.

8.2.13. Risk Presentation

Individual Risk:

The Individual Risk calculation can be done using the specific locations of the known sources at the establishment. The Individual Risk represents the frequency of an individual dying due to loss of containment events (LOCs). The individual is assumed to be unprotected and to be present during the total exposure time. The Individual Risk is presented as contour lines on a topographic map.

Societal Risk:

The Societal Risk calculation can be done using the specific locations of the known sources at the establishment and outside the establishment. The Societal Risk represents the frequency of having an accident with N or more people being killed simultaneously. The people involved are assumed to have some means of protection. The Societal Risk is presented as an FN curve, where N is the number of deaths and F the cumulative frequency of accident s with N or more deaths.

Ignition Probabilities

The event failure frequency of LOC scenarios are listed below. Sources of event failure frequency are from CPR 18E and OGP database.

Table 8-16 Accident event frequency

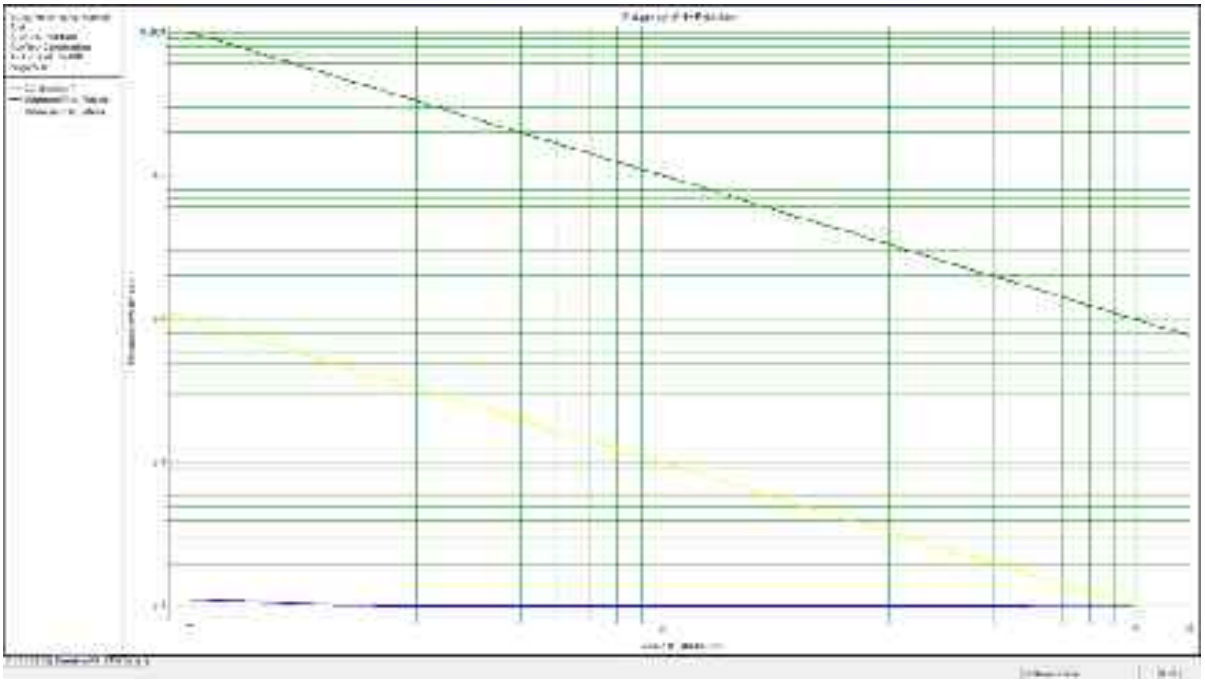
S. No	Scenarios	Failure frequency (per year)
Diesel Hydrodesulphurisation (Revamp)		
1	Leak of R-101 (Third HDS reactor)	1.00E-06
2	Rupture of R-101 (Third HDS reactor)	5.00E-08
Gasoline Hydrodesulphurisation (Revamp)		
3	Leak of 307-C-101 (N) (Second stage amine absorber)	1.00E-06
4	Rupture of 307-C-101 (N) (Second stage amine absorber)	5.00E-08
CCRU		
5	Leak of 014-R-1 (Hydrotreater reactor)	1.00E-06
6	Rupture of 014-R-1 (Hydrotreater reactor)	5.00E-08
7	Leak of 015-R-3 (Third Reforming reactor)-Reactor section	1.00E-06
8	Rupture of 015-R-3 (Third Reforming reactor)-Reactor section	5.00E-08
9	Leak of 015-P-3 (A/B) (Stabilizer Feed pumps)-Fractionation section	2.50E-06
10	Rupture of 015-P-3 (A/B) (Stabilizer Feed pumps)-Fractionation section	5.00E-07
Isomerisation		
11	Leak of 2112-C-01 (Naphtha Splitter-1)	1.00E-06
12	Rupture of 2112-C-01 (Naphtha Splitter-1)	5.00E-08
13	Leak of 2112-C-03 (FCC Heart cut Naphtha Splitter)	1.00E-06
14	Rupture of 2112-C-03 (FCC Heart cut Naphtha Splitter)	5.00E-08
15	Leak of 2112-C-04 (NHT Stripper)	1.00E-06
16	Rupture of 2112-C-04 (NHT Stripper)	5.00E-08
17	Leak of 2112-K-02 (A/B) (NHT Make up gas compressor)	4.70E-05
18	Rupture of 2112-K-02 (A/B) (NHT Make up gas compressor)	6.70E-05
19	Leak of 2113-R-02 (A/B) (PENEX reactor)	1.00E-06
20	Rupture of 2113-R-02 (A/B) (PENEX reactor)	5.00E-08

8.2.14. Risk Contours

1. Diesel Hydrodesulphurisation (Revamp)

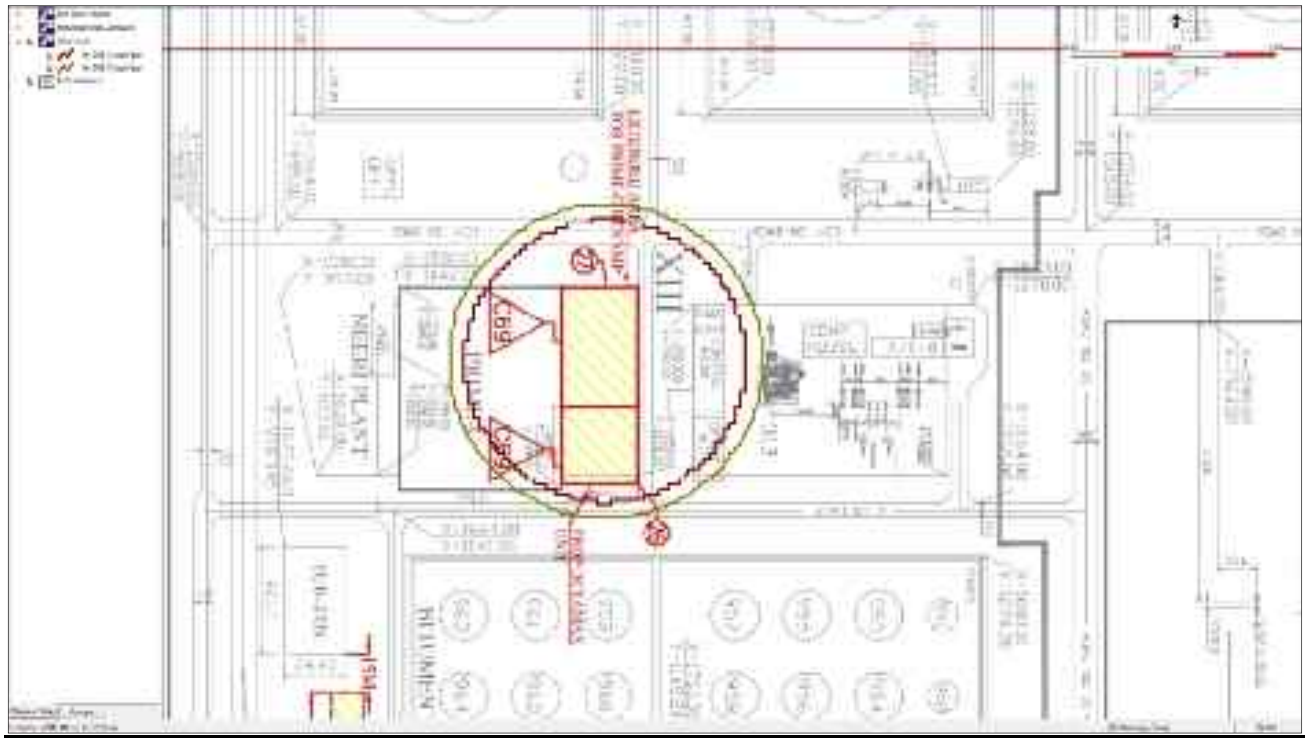
Individual Risk: 9.87E-08/avg.year

Societal Risk:



2. Gasoline Hydrodesulphurisation (Revamp)

Individual Risk: 1.72E-08 /avg.year

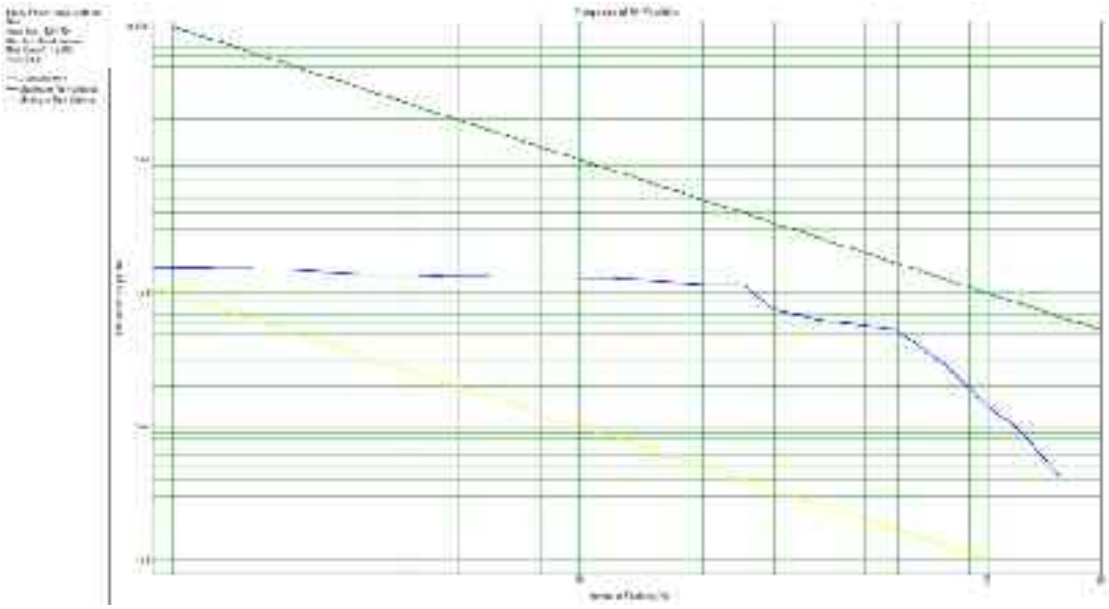


Societal Risk:

3. CCRU and Isomerization unit

Individual Risk: 1.17E-05 /avg.year

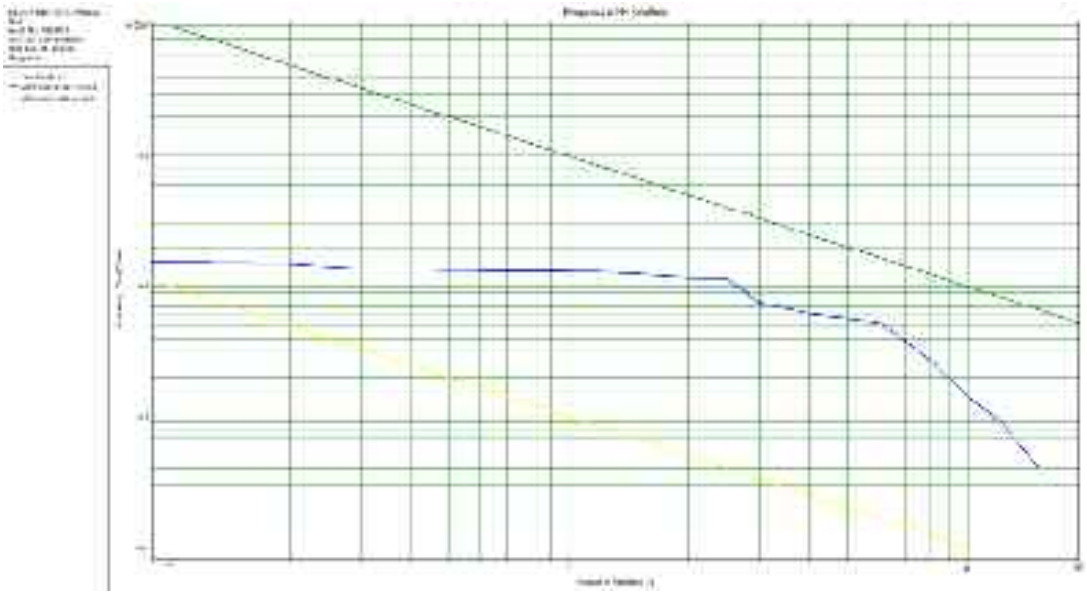
Societal Risk:



3. CCRU and Isomerization unit

Individual Risk: 1.17E-05 /avg.year

Societal Risk:



8.2.15. Risk Acceptance

In India, there are no defined criteria for risk acceptance. However, in IS 15656 – Code of Practice for Hazard Identification and Risk Analysis, *Annexure E* summarizes the risk criteria adopted in some countries. Extracts for the same is presented below:

Table 8-17 Risk Criteria in Some Countries

Authority and Application	Maximum Tolerable Risk (Per Year)	Negligible Risk (Per Year)
VROM, The Netherlands (New)	1.0E-6	1.0E-8
VROM, The Netherlands (Existing)	1.0E-5	1.0E-8
HSE, UK (Existing Hazardous Industry)	1.0E-4	1.0E-6
HSE, UK (New Industries)	1.0E-5	1.0E-6
HSE, UK (Substance Transport)	1.0E-4	1.0E-6
HSE, UK (New Housing Near Plants)	3 x 1.0E-6	3 x 1.0E-7
Hong Kong Government (New Plants)	1.00E-5	Not Used

To achieve the above risk acceptance criteria, ALARP principle was followed while suggesting risk reduction recommendations

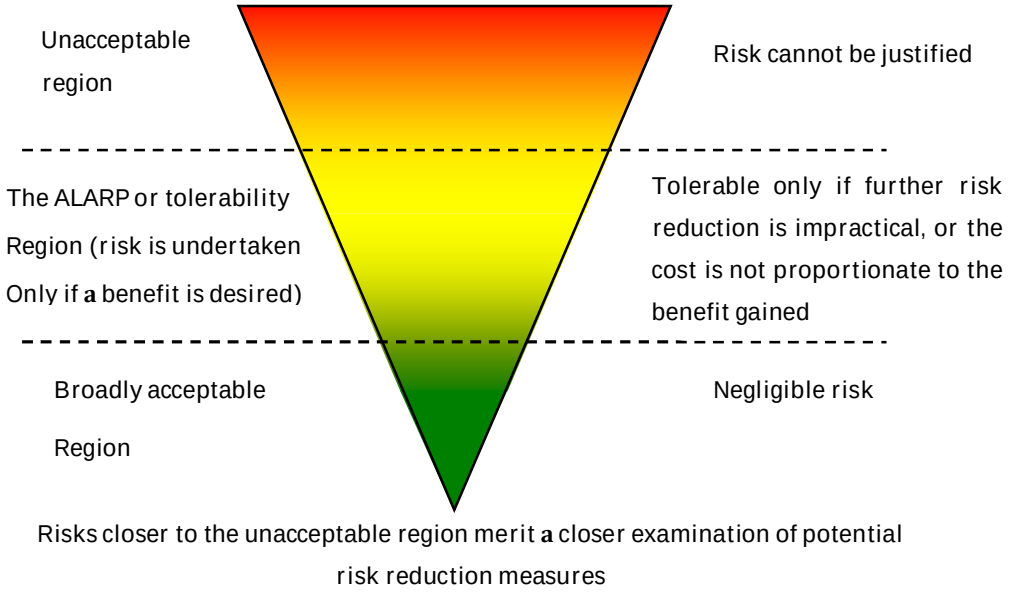


Table 8-18 Risk Summary

S. No	Location	Individual Risk /avg.year
1	Diesel Hydrodesulphurisation (Revamp)	9.87E-08
2	Gasoline Hydrodesulphurisation (Revamp)	1.72E-08
3	CCRU and Isomerisation unit	1.17E-05

Legend:

Unacceptable	ALARP	Acceptable

With reference to the risk acceptance criteria specified by HSE, UK in IS 15656:2006 - Code of Practice on Hazard Identification and Risk Analysis it is observed that the risk levels of Diesel Hydrodesulphurisation (Revamp) and Gasoline Hydrodesulphurisation (Revamp) are in Acceptable and CCRU and Isomerization unit are in ALARP regions. The risk levels in ALARP are expected to come down to acceptable limits if all the control measures recommended in this report are implemented in addition to the existing risk control measures. It is highly recommended to conduct full scale Quantitative Risk Assessment during subsequent stages of the project with validated data to ascertain the impact of the units.

8.2.16. Risk Control Measures Suggested

Diesel Hydrodesulphurisation (Revamp)	Individual Risk : 9.87E-08/avg.year
Affected areas: 1. Control Room near DHDS 2. DHDT	
Study observation: 1. Control room near DHDS falls under overpressure effect region between 0.1 bar and 0.03 bar.	Existing Risk Reduction Measures: 1. Control room near DHDS is designed after considering design blast load of 3 psi as per OISD-STD-163. 2. Passive fire protection has been provided for the structures at DHDT. Additional Risk Reduction Measures: 1. Hydrocarbon gas detectors are to be provided in HDS reactor area of DHDS. 2. H2S gas detectors are to be provided in the HDS reactor area.

Gasoline Hydrodesulphurisation (Revamp)	Individual Risk : 1.72E-08/avg.year
Affected areas: 1. Trans. S/S-9 Control room and 2. Office building near Compressor house.	
Study observation: 1. VCE due to leak of 307-C-101 (N) - Second stage amine absorber is reaching up to a maximum of 29.0 m at 0.1 bar and 24.5 m at 0.3 bar at 1 F Weather condition.	Risk Reduction Measures: 1. During the subsequent stages of the project, the location of second stage amine absorber to be finalized to ensure minimization of over pressure impact on the Control room and office building near compressor house.

	2. Hydrocarbon gas detectors are to be provided in Prime-G area. 3. H2S gas detectors is to be provided in the amine absorber area.

CCRU and Isomerisation unit	Individual Risk : 1.17E-05/avg.year
Affected areas: 1. CCRU/ISOM/ETP NEW S/S 2. LPG filling shed 3. LPG Spheres	
Study observation: 1. CCRU/ISOM/ETP NEW S/S is present in the LFL region of the flammable cloud. 2. Jet fire impact is reaching LPG filling shed. 3. Overpressure at 0.3 bar is covering LPG Spheres.	Risk Reduction Measures: 1. As per OISD-STD-113, flameproof electrical fittings are to be provided based on hazardous area classification. 2. Consider relocation of LPG filling shed as it is exposed to Jet fire, VCE scenarios. 3. Hydrocarbon gas leak detection system in new CCRU and ISOM unit to be ensured. 4. Hydrocarbon gas detectors are to be provided in Naphtha splitter, NHT stripper and PENEX reactor area reactor area 5. As per OISD-STD-164 passive fire protection should be provided for nearby process facility structures and equipments and passive fire protection layout drawing has to be prepared.

General Recommendations
1. Ensure that work permit system for hot work is in place as ignition control. 2. Ensure Self Contained Breathing Apparatus along with the spare cylinders are available in sufficient numbers for the operators for use during any leakage. 3. Disaster Management Plan should be prepared considering risk contribution due to new units and the responsibility of persons from different departments available on the site should be clearly mentioned. 4. Ensure mutual training sessions and mock drills related to first aid, fire fighting and evacuation

should be conducted to appraise and train different levels of responders in emergency control.

8.2.17. Conclusion

The above risk control measures are recommended in addition to the existing risk control measures to maintain the risk levels within acceptable region.

8.3. Emergency Response and Disaster Management Plan

Emergency Response & Disaster Management Plan (ERDMP) of Mathura Refinery accredited from the Petroleum & Natural Gas Regulatory Board (PNGRB) by M/s Disaster Management Institute (DMI), Bhopal on 19th June 2012. Both On-site and Off-site disaster drills are conducted as per statutory norms.

Effective Emergency Response plans and Disaster Management Plan are already in place and the same will be updated based on the recommendation from the risk assessment studies.

9. PROJECT BENEFITS

9.1. Introduction

This project, besides general economic desirability, would result in substantial socioeconomic benefit to the country in general and more specifically to the region. These socio-economic benefits are described hereinafter.

9.2. Contribution to the Nation

India has been witnessing rapid urban and industrial growth in the past two decades, and with the country's current liberalization policy, this growth is expected to accelerate further. As a consequence of the rapid rate of industrialization in India, petroleum products needs are increasing at an equally rapid rate and the supply-demand gap is widening and steps must be taken to address this issue. The proposed project will result in the supply of increased volumes of environmental friendly petroleum products to meet the energy security of northern, western and southern region of the country.

9.3. Increased Production of BS VI Grade

As far as diesel is concerned, major changes from BS I to BS II, III & IV were made in respect of density, Cetane number, sulphur, distillation recovery including criterion for limiting Polycyclic Aromatic Hydrocarbon (PAH) as per auto fuel policy.

The proposed project is for the Quality Improvement Project from BS-IV to BS-VI grade at the same crude processing capacity of 8 MMTPA to reduce sulphur content from 50 ppmw to 10 ppmw. The MS and HSD complying with BS VI specification are environmental friendly fuels.

9.4. Socio-economic Development

The proposed project would generate some direct and indirect employment opportunities during construction, which will benefit the local economy. No additional manpower is envisaged in the project as the project will be integrated with existing refinery. However local skilled and unskilled labour will be required during construction phase. Improvement in the overall socio-economic status of the vicinity of project area, in the thematic areas of health, education, livelihood and infrastructure is expected.

10. ENVIRONMNETAL MANAGEMENT PLAN

10.1. Preamble

This chapter presents an overview Environmental Management Plan and Environmental Monitoring Program.

The Environmental Management Plan (EMP) is required to ensure sustainable development in the area of the project site. EMP also ensures that the project implementation is carried out in accordance with the design and the mitigative measures as recommended in the Environment Impact Assessment study to reduce the adverse impacts during the project's life cycle. The plan outlines existing and potential problems that may adversely impact the environment and recommends corrective measures where required. The identification and quantification of impacts based on scientific and mathematical modeling have been presented in Chapter 4.

Mitigation measures at the source level and an overall EMP for the study area are planned for implementation, to improve the supportive capacity of the study area and also to preserve the assimilative capacity of the receiving bodies.

10.2. EMP Structure

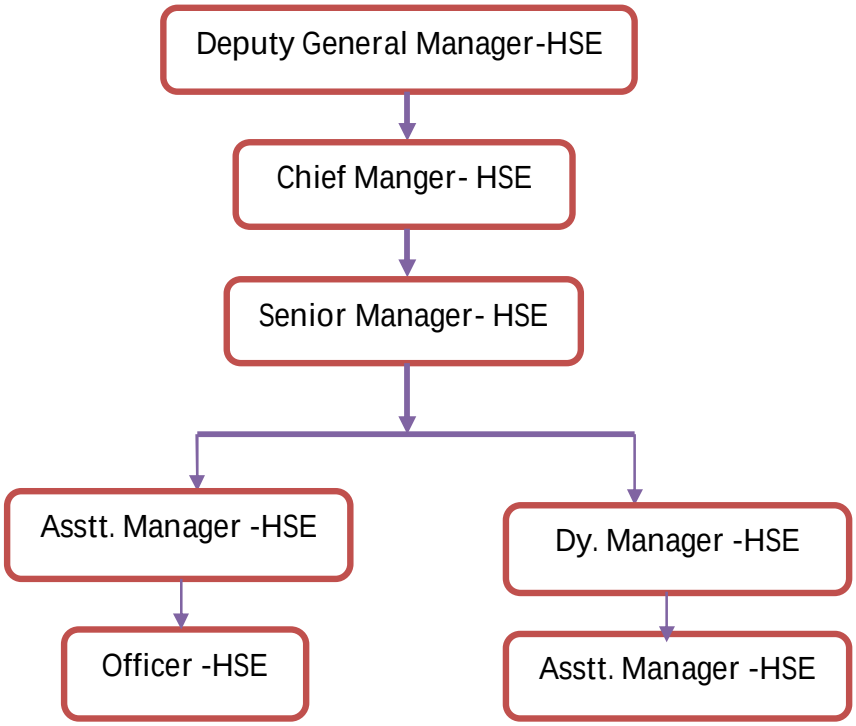
This EMP is designed as an overriding document in a hierarchy of control plans, and sets out the overarching framework of environmental management principles that will be applied to the project during preconstruction, construction and operation phase of the project.

The EMP contains guiding environmental principles and procedures for communication, reporting, training, monitoring and plan review to which all staff, contractors and subcontractors are required to comply with throughout the preconstruction, construction and operation phases of the proposed quality improvement program.

IOCL Mathura Refinery Plant has been implementing a sound Environmental Management Program and achieving environmental leadership. A robust environmental monitoring and compliance adherence process have been established by IOCL across their Mathura facilities. The Environmental Management activities are being implemented by the support staff of dedicated environmental management cell headed by a Deputy General Manager. The environmental management procedures and

standard operating procedures that are currently adopted in the existing facilities will be adopted during the design, construction and operational phases of the quality improvement project.

Figure 10-1 Environmental Management Cell



10.3. Environmental Management Plan during Construction Phase

Since the proposed project is only quality improvement program, no additional land would be acquired, revamp of existing units shall be carried out in the plot area of existing Prime-G, HGU-1 and DHDS units, and new units CCR and ISOM will be installed in the available bare land at southern side of existing refinery plot area. Therefore no displacement of settlements, flora and fauna has been envisaged.

The nominated contractor will be primarily responsible for implementing the site specific construction related EMP under the guidance and supervision of IOCL Environment Management team. IOCL has developed various well proven and demonstrated construction work methods to ensure safe working environment and minimize adverse environmental impacts. The same will be adopted in the quality improvement program. IOCL will adopt the construction phase Environmental Management Plan.

10.4. Environmental Management Plan during Operation Phase

During the operation phase, the impacts on various environmental attributes should be mitigated using appropriate pollution control equipment. The Environmental Management Plan prepared for the proposed project aims at minimising the pollution at source.

10.4.1. Air Quality Management Plan

The proposed project is an environment friendly technology with marginal increase in the pollution load from the current levels. The total emission of SO_2 from the existing refinery complex is stipulated to 339.8 Kg/Hr. Although insignificant raise in SO_2 emissions will be envisaged due to utilization of natural gas and fuel gas as a base fuel in the captive power plant for the additional power requirement for the proposed revamp. Ground level concentrations of SO_2 are predicted which is well within limits of 450 Kg/hr.

Existing air quality management facility is adequate to control the marginal increase in SO_2 emission. Flare tip is designed to ensure smokeless conditions. Adequate stack height will be designed for the proposed unit in consideration with the “Guidelines for Minimum Stack Height" as per notification by MoEF dated 19th May 1993, which fixes the minimum stack height based on emission of Sulphur Dioxide. Ambient air quality is monitored regularly and LDAR program is implemented to detect leakages and VOC emissions.

No major process vents and fugitive emissions are envisaged from proposed quality improvement project. However, the currently adopted plant wide Leak Detection and Repair Program will be extended to control fugitive VOC emissions, thereby achieving the emission standards.

10.4.2. Noise Management Plan

The statutory National Standards for Noise Levels at the plant boundary and at areas near the plant have been met. The selection of plant equipment has been done with specification of low noise levels. Noise suppression measures such as enclosures, buffers and / or protective measures has been provided to limit noise levels within occupational exposure limits (OSHA) or equivalent standards). Areas with high noise levels are identified and segregated and wherever possible included prominently using

display caution boards. Measures for noise control at the design stage have been followed in terms of the following:

- Noise levels specification of equipment shall be limited to noise to 85dB (A) at a distance of 1m
- Equipment layout has been done considering the segregation of high noise generating areas.
- Suitable enclosures have been provided, wherever required, to minimize the impact of high noise generating sources
- Avoiding continuous (more than 8 hrs) exposure of workers to high noise areas.
- Provision of ear muffs at the high noise areas
- Ensuring preventive maintenance of equipment.

10.4.3. Water & Wastewater Management Plan

Water conservation is one of the policies adopted at Mathura Refinery. The proposed project will require water to the tune of 11m^3/hr and this requirement will be met by recycling of treated effluent. No fresh water will be withdrawn to meet the requirement of water for the proposed project. Increased wastewater recycling through new Filtration system at ELR

10.4.4. Ecological Environment

Massive afforestation activities have been undertaken by Mathura Refinery and the green cover also enhances the aesthetic look. Mathura refinery has planted 1, 67,000 tress in the surroundings area including refinery & township. About 1,15,000 trees have been planted in the Agra region around Taj Mahal. The detailed discussion on the ecological parks with photographs is given in Section 2.9 of Chapter 2.

IOCL have been implementing a sound Environmental Management Plan (EMP) at its existing facilities of Mathura Refinery complex. The Environmental Management Programs are being effectively implemented by the environmental team headed by a General Manager. IOCL complies with applicable environmental regulations and guidelines at its existing facilities. In addition, IOCL has been practicing good engineering and management practices at all stages of its project, planning, design, construction and operational phases of the facility. EMP for the FCCU revamp project was already developed and incorporated in the design of the facility as per the recommendations made in the EIA Report, February 2006. EC has been granted by MoEF letter no. J-11011/283/2006-IA II (I) dated 22nd March 2007.

Construction Management

The overall impact of the pollution on the environment during construction phase is localized in nature and is for a short period. However, the control of Environmental pollution during construction phase even though for a shorter period is of vital importance. The required mitigatory measures with respect to specific activities during construction phase are considered.

Environment Management in the Operation Phase

The overall impact of the pollution on the environment during operational phase is only marginal addition on various components of environment. The required mitigatory measures with respect to specific activities during operation phase are considered like proper operational practices, construction of treatment plant for treatment of waste water etc.

In order to keep a check on the emissions of SO_2, NO_x, SPM and CO from all the point sources, all stacks shall be monitored as per statutory regulations. At present ambient air quality of the complex and the surrounding area is measured on continuous/periodic basis with monitoring stations which are identified on the basis of micro-meteorological conditions and human settlement data as susceptible zones. The pollutants monitored are SPM, SO_2, NO_x, and HC. The monitoring of these pollutants will be continued in future also. As the plant is going to be operational on a 24-hour basis, noise considerations are very important. All equipments will be specified to meet 90 dB (A) at 1 m distance. As incorporated during the design stage, the plant areas

where noise levels are high enough to cause operations some adverse impacts, the usage of ear plugs or ear muffs shall be strictly enforced. The exposure of employees working in the noisy area shall be monitored regularly to ensure compliance with the OSHA requirements.

At present, a comprehensive water quality monitoring is carried out for physio-chemical and micro biological parameters (i.e. pH, Oil & Grease, SS, DO, COD, BOD, Sulphide, Phenol) at the inlet and outlet of the existing Effluent Treatment Plants. This monitoring shall be continued in the post project scenario also.

Efforts shall be made to promote harmony with the local population and further consolidate their positive perceptions of industrialization. Thru' CSR activities, Refinery has been role model for implementing social welfare scheme. Various activities such as health & medical care, road construction, assistance to school/training centers, drinking water etc is being taken-up every year. Expenditure on CSR activities is approx.1 crores. Annual average expenditure for running a 50-bed hospital 'Sawarn Jayanti' is about 2.75 crores.

M/s IOCL is already having an Environment Cell under its technical services department which is headed by a well qualified and experienced technical person from the relevant field. He is directly reporting to the Head of the Technical Services department. The cell carries out number of activities related to effluent treatment and monitoring of treated effluent, ambient air quality and stack emissions. The cell also has an analytical laboratory under its control to carry out the analysis of air & water samples. The lab has requisite technical staff to carry out these analyses.

IOCL Mathura Complex has always contributed to sustainable development. Various green initiatives have been taken from time to time which are testimony towards our endeavor to be seen as environmentally responsible company. Awards are given by various reputed environmental organizations to IOCL in past in various fields.

To further confirmation of the contribution of IOCL to the natural environment as green belt is that the environmental studies would be very much incomplete if proper attention is not provided towards project's impact foreseeable on flora and fauna of the study area. Ecological monitoring will be beneficial to proponent as well as populations

in the vicinity of development as a tool for better prospecting and conservation of species or resources for sustainable long-term use.

For example gradual removal and eradication of Prosopis juliflora (a exotic alien species) seen in the ecological park and replace them with the native species should enhance the biodiversity, aesthetic value and attract additional avian fauna and butterflies to the eco-park of IOCL. In view of the above following scope of work was delineated for the ecological studies of 2 km radius area from project site should be demarcated as core zone and 10 km radius from project site will be demarcated as buffer zone. A three seasons comprehensive monitoring should be carried out in the study area covering terrestrial as well as aquatic biota.

The objective is not just to create an inventory of the plant and animal species that are present but to evaluate the overall biodiversity importance. Often the most significant challenges of baseline assessments are to incorporate spatial and seasonal variations, as insufficient time may be available to develop an accurate assessment. Season wise ecology was studied in following manner. Biodiversity monitoring is most often undertaken in conjunction with specific management programmes to inform when intervention is required and to determine whether it has been successful.

10.4.5. Corporate Social Responsibilities

It strives for sustainable development which is the key for building a framework that would lead to economic growth, social equity, and efficient management of resources and environment. Indian Oil's Sustainability & CSR vision is to operate its activities in providing energy solutions to its customers in a manner that is efficient, safe & ethical, which minimizes negative impact on environment and enhances quality of life of the community, towards sustaining a holistic business.

CSR Progression

Indian Oil has increased the contribution towards CSR activities with time. The budget for CSR has gradually increased from 0.5% of previous year's Net Profit (which was in place since 1991) to 2% of previous year's Retained Profit (from 2009 onwards). With promulgation of Companies Act, 2013 and rules thereof, Indian Oil has aligned its CSR activities and polices as per the Act.

Indian Oil Sustainability Initiatives

Sustainable development is the only way forward for growing economies like India and Indian Oil, views this responsibility with utmost commitment. Though these initiatives are not funded through CSR budget, but are supportive in development of communities at large. Energy conservations are one of the major initiatives of corporation. It shall help in redistribution of resources and providing a greener environment to the community.

The existing various CSR activities carried out by Mathura Refinery is detailed in Section 2.16 of Chapter 2.

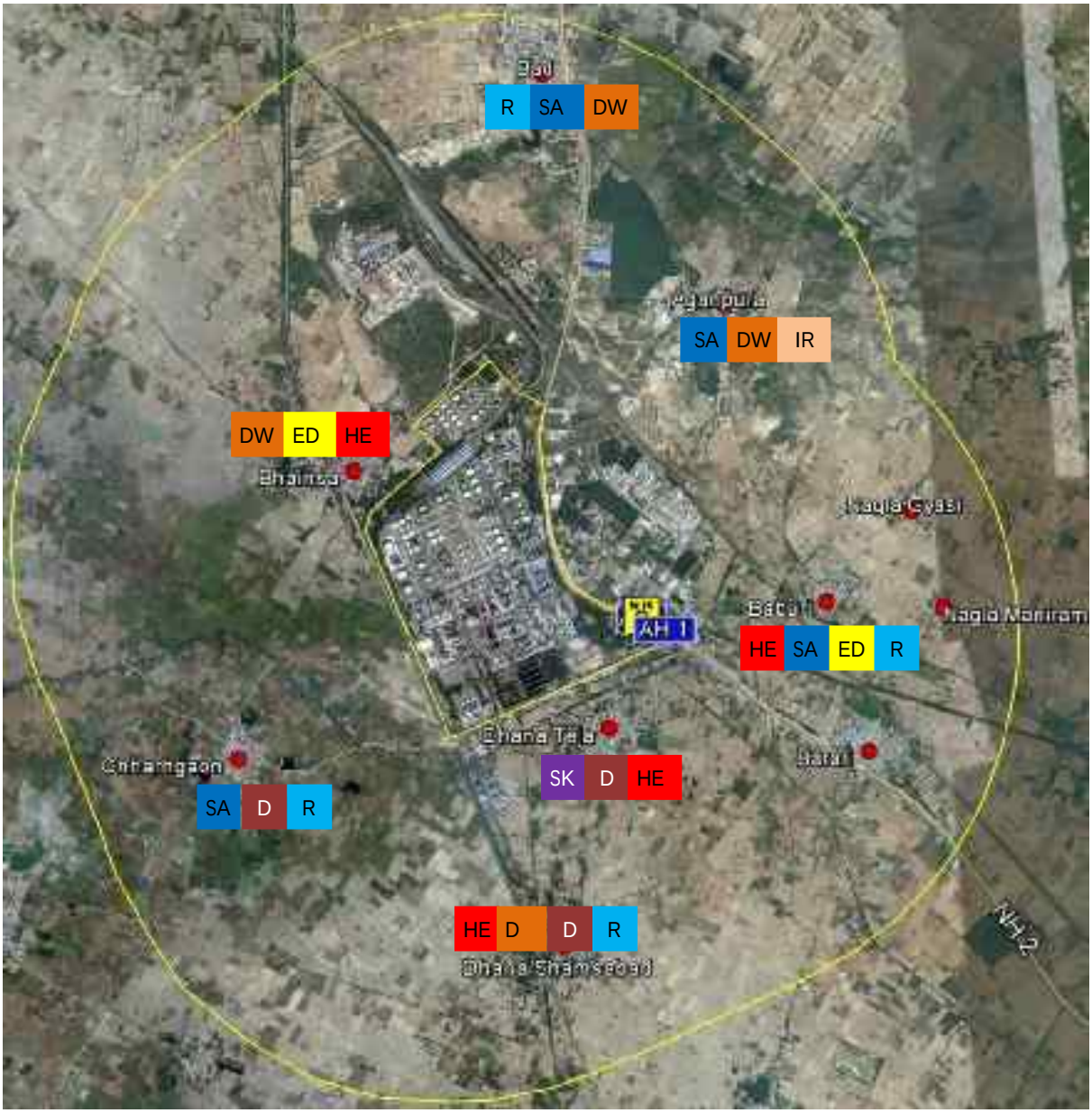
Proposed CSR Activities

The proposed CSR activities are based on the socioeconomic indicators, field observations and based on the felt needs of the people during the primary survey. The need based CSR programs are proposed for the villages adjacent to the project site.

Village wise Need Based Programs

The below are the village specific infrastructure development programs; however the other CSR development programs are common of all the villages in the study area. In the present study, only villages falling with the direct impact zone is considered. However the CSR program can be extended to the other parts of the study area where ever the CSR committee decides.

Figure 10-2 **Village wise Need Based Programs**



10.4.6. CSR Budget

The capital CSR budgets of Rs. 6045 Lakhs had been embarked for the local Community development within the vicinity of the study area as budget classification given below in Table10.1. The capital budget is arrived by considering 3.5 % of the total project cost of

Rs. 1713 crores as per the Project Cost estimate.

Table 10-1 Proposed CSR Budget for the Year 2017-2023

SNO	CSR Project/ Activity identified	Budget (in lakhs) 2017-2018	Budget (in lakhs) 2018-2019	Budget (in lakhs) 2019-2020	Budget (in lakhs) 2021-2022	Budget (in lakhs) 2022-2023
a)	CSR Activities **(** New Activities)					
1	Health **&** Medical Care:					
	Disabled Camp (Distribution of Tri-cycle, Hearing -aid, etc)	6.00	6.00	6.00	6.00	6.00
	Medical / eye camp nearby villages	10.00	10.00	10.00	10.00	10.00
2	Education					
	Dual desk in various Village Schools	18.00	18.00	18.00	18.00	18.00
	Paver Block work in nearby village schools	20.00	20.00	20.00	20.00	20.00
	Room Construction for Physics & Chemistry Lab in a School	20.00	20.00	20.00	20.00	20.00
	Construction of two hostel rooms for blind students at Surkutir, Keetham	15.00	15.00	15.00	15.00	15.00
3	Drinking Water **&** Rural Development					
	Construction of Lanes & Drains in nearby villages Bhainsa, Dhanateja & other nearby villages	40.00	40.00	40.00	40.00	40.00
	Installation of Hand Pumps in nearby villages (50 nos)	20.00	20.00	20.00	20.00	20.00
	LED Solar street lights : 80 no's in nearby Villages	20.00	20.00	20.00	20.00	20.00
4	Skill Development Program					
	Nursing education to girls through RKMS for 30 students each /year, Pan India (Sponsoring a batch of 30 Girls students per year under MOU with RKMS for 10 years)	9.00	9.00	9.00	9.00	9.00
5	Impact Assessment **&** Branding					
	Building a Public image of the Company in public perception (Sinage, CSR film etc.,)	5.00	5.00	5.00	5.00	5.00
	Impact assessment of CSR activities /Baslineline Survey/Promotional	15.00	15.00	15.00	15.00	15.00
b)	CSR Initiatives at Chandrabhan Nagla, Farah					
	Flooring Work platform / civil work at Deen Dayal Dham	6.00	6.00	6.00	6.00	6.00
	Solar Power Station 10 / 15	10.00	10.00	10.00	10.00	10.00

	KVA					
c)	Swachha Bharat / Vidhayalya Abhiyan (Construction/Renovation of Toilets)					
	Toilets in nearby village schools (5 nos.)	30.00	30.00	30.00	30.00	30.00
	Toilets in nearby village Aurangabad for ladies (03 blocks each)	20.00	20.00	20.00	20.00	20.00
d)	Swarana Jayanti Samudaik Hospital (SJSH)					
	Release of Grant to SJS Hospital	550.00	550.00	550.00	550.00	550.00
	Civil / Electrical Maintenance work SJSH	50.00	50.00	50.00	50.00	50.00
e)	Kendriya Vidyalaya School (KVS)					
	Kendriya Vidyalaya (10 % Esc + Arrier of Rs. 25 lakhs included)	345.00	345.00	345.00	345.00	345.00
G. Total		1209.00	1209.00	1209.00	1209.00	1209.00
Total of **5** years		6045.00				

10.5. Budgetary Cost Estimates for Environmental Management

The estimated cost of the various items under environmental management programs will be in the order of Rs. 260.05 Lakhs. Break-up of the budget for the proposed project environmental management programmes are presented in Table 10.2

Table 10-2 Proposed Budget for Environmental Management Plan

S.No.	Activity	Budget, 17-18 (in lakhs)
A	Monitoring Activities	32.55
1	Stack, Sludge and Outside Ambient Air Monitoring	6.00
2	Ground Water Monitoring	0.55
3	LDAR program (VOC Monitoring)	6.00
4	Any other monitoring activity	20.00
B	Awards in field of Environment Mangement	2.50
C	Statutory Fees	42.50
1	Consents	12.50
2	Water CESS	30.00
D	Tree Plantation	15.00
1	Tree Plantation (2500 nos)	5.00
2	Maintanence, Tree Guards and Other expenses	10.00
E	Waste Disposal	35.00
1	Bioremediation	20.0
2	Waste Disposal to Outside approved parties	15.0
F	Promotional Activities	7.50
1	World Environment Day	3.50
2	Environment Workshop etc	4.00

S.No.	Activity	Budget, 17-18 (in lakhs)
G	Consultancy / Study Jobs	100.00
H	Unplanned EP jobs	25.00
	Total (A+B+C+D+E+F+G) (Fig in lacs)	260.05

10.6. CSR Programs Implementation Strategies

10.6.1. Community Development Organization

This section of the report presents the strategy to be followed in implementing various pre-defined CSR Plans. For this, a universally accepted principles recommended by World Bank Group (WBG) (ref)[4] have been referred. Once the key community development areas have been identified, the critical aspects to be addressed are - when to invest in communities, how to invest, constitution of the implementing team and how to monitor the effectiveness of the program.

10.6.2. .Formation of Core CSR Management Team

The first step in the community investment programs is to form a central CSR management team within IOCL, which shall be supported by a group of social scientists headed by a functional head to implement and monitor the overall program. The primary responsibilities of the central CSR management team is to define the specific yearly investment programs, identifying various vehicles and appointing stake-holders to successfully implement the individual schemes, allocating and disbursing funds to the respective stake-holders and implementation agencies in appropriate time, periodical interactions with communities and understand the effectiveness of the overall programs and finally undertake audits through external agencies to assess the adequacy of the implementation strategies to meet the specified objectives. A clearly defined community investment plan policy shall be developed by IOCL every year to define the objectives, targets, roles and responsibilities of the individual stake-holders. The policy should be developed based on the following key performance objectives:

- Set out a 3-5 year plan for the company's community investments
- Identify target stakeholder groups and specify eligibility criteria for each of the

[4] *Strategic Community Investment, A Good Practice Handbook for Companies Doing Business in Emerging Markets, International Finance Corporation*

identified scheme

- Establish an iterative process of engagement with local stakeholders and partners on community investment
- Draw on the company's core competencies and resources to support communities
- Promote cross-functional coordination and accountability for supporting community investment objectives
- Identify the implementation model and decision-making/governance structures
- Define roles and responsibilities, budget, scope, and timeline
- Describe how project results will be monitored and communicated

10.6.3. Identifying and Nominating the Implementing Agencies

Assessing who is who and which organizations could be potential partners for community development programs is an important part of understanding the local context. Partnerships are a cornerstone of strategic community development program. Ideally, they should be pursued in the early planning stages as a part of a company's sustainability and exit strategies. Wherever possible, it is good practice to explore working through existing reputed Non Governmental Organizations (NGO) or programs before creating new ones. These agencies can be selected based on the following criteria: Ability to reach the local people and areas, thematic areas of expertise - health, capacity building, sanitation, etc. Delivery capacity, including staffing, existing relationships, contacts, and networks with local areas and communities, Core values (which should be compatible with the company's objectives and principles) reputation and track record.

10.6.4. Constituting Village Development Committees

The key beneficiaries of the community development programs are the needy local villagers. Therefore, the local communities shall be completely involved in various designated programs. It has been recommended to form local village bodies such as youth association groups, fishermen association group, women group, village develop group, etc. Each of these groups will be defined with the basic constitution of the committee, specific roles and responsibilities. Each group should comprise of at least three members from various sections of the village. The roles and responsibilities of

these groups is to undertake awareness programs among the villagers about the respective schemes, providing local support while implementing the schemes in association with the nominated implementing agency or NGO, etc., providing feedback to IOCL. on the overall progress of the scheme, grievances, if any and suggestion and recommendations for the effective implementation of the schemes. Monthly progress review meetings with respective stakeholders of the individual schemes are essential to ensure smooth implementation of the designated schemes.

10.6.5. Fund Allocation and Disbursement

Based on the well planned community development programme, adequate annual budget shall be allocated for community development plan and the same shall be credited in a dedicated account to ensure continuous flow of funds throughout the year without any interruption. Required funds for the respective programs can be allocated on a monthly basis to the nominated implementing agencies based on the monthly work progress reviews with respective stake holders. An external CSR consultant can be nominated for project cost estimations, verification of the schemes proposed and also to monitor the overall programs.

An implementation or delivery model is the organizational structure through which a company carries out its community investment program or supports others in doing so. In practice, many companies use “hybrid” approaches—a combination of different mechanisms to deliver their programs. The following schemes can be adopted for effective community development investment.

- In-house Implementation - Company creates an internal department or unit to work directly with communities to design and implement community development schemes. Schemes for developing infrastructure such as roads, sanitation facilities, construction of buildings, hospitals, etc. can be taken up under this mode.
- Company Foundation - Company establishes an independent foundation as a separate legal entity to carry out its community development programs. Foundations can have grant-making authority (i.e., financing of community development programs implemented by others) or serve as an implementing function (implementing their own projects and programs).

- Third-party Implementation - Company engages a third party, such as NGO or group of NGOs, to work with local communities in designing and implementing schemes or it supports an existing initiative being implemented by others.
- Multi- Stakeholder Partnership - Company establishes or joins a voluntary or collaborative alliance, network, or partnership. This implies cooperation between two or more partners in a manner that shares risks, responsibilities, resources, and competencies, and involves a joint commitment to common tasks and goals. Schemes such as social forestry programs, restoration of lakes and canals and disaster management infrastructure facilities, etc. can be taken up under this scheme.
- Hybrid Models - Company utilizes a combination of two or more implementation models to deliver various components in the community development program.

10.6.6. CSR Activity Monitoring, Reporting and Continual Improvement

The CSR management team of the IOCL should develop monthly, quarterly, half yearly and annual status reports for adopting necessary corrective actions for continuous improvement.

A suitable system to monitor the whole process with regard to the performance at the field levels shall be established. This system can be developed within the CSR department who will be assigned to do periodic evaluation. This process should be intimated to the nominated Implementing Agencies in their work order. The monitoring and evaluation shall be taken at different levels i.e. CSR department, with Implementing Agencies, within community, etc. The various field functionaries would be familiarized with the basics of this reporting system as well as their role and responsibility. The Monitoring and Evaluation team's responsibilities are as follows: Periodic Progress Reports, Necessity and the periodicity of such reports, Output to be generated, Evaluation, Improvement / Development of Implementation process, Analyzing deviations to the said objectives, Focusing on Qualitative aspects in progress of project and Identifying Changes / Milestones in development

Annual bench mark surveys can be carried out with selected villages to assess the overall outcome and benefits of the CSR programs implemented in the respective areas

as per the pre defined CSR objectives. The findings of the study can be compared with the ratings prior to the entry of development activities. The following parameters can be considered for evaluating the overall outcome and performance of the community development programs implemented in a specific period:

1. Increase income level of the BPL families,
2. Increase in literacy level,
3. Reduction in infant mortality and ailments of humans and cattle,
4. Increase in fish production,
5. Reduced population migration,
6. Increased sanitation and drinking water facilities etc.

Other indicative parameters that shall be included in the evaluation of the overall performance of the CSR program are listed hereunder:

- Number of protests, demonstrations, complaint letters, and compensation requests
- Number of community participants in consultation meetings
- Closures of activities due to a disturbance by the community/local stakeholders
- Quantity of work applications received from the community/local stakeholders
- Incidents (related to communities or other stakeholders) affecting company property or personnel
- Number of problems or grievances identified by local stakeholders
- Quantity—and the time period of delays in implementing the schemes
- Community sentiment surrounding current community development initiatives (i.e., Do they fulfill needs and expectations?)
- Effectiveness of public consultation activities (i.e., Do local people feel their participation has value?)
- Degree of trust felt by the community toward the company (and vice versa)
- Positions taken by the local government regarding decisions that affect the company
- Community members say they are better off as the result of the company's presence
- Number of positive and negative press articles about the company

If measuring value of the community development is important, communicating that value is equally important. For benefits derived from community development to be optimized, stakeholders at the local, regional, and international levels need to know about these investments and the value they create. The annual reports of the CSR shall be communicated to all the concerned stake holders such as company employees and community, investor community, local Communities and Other Stakeholders (government, NGOs, media). The annual reports should address the community development programs implemented, impact on the business, the outcome and benefits of schemes to local villagers and community. Various communication models can be adopted such as Television, road, booklets and magazines, press meets and conferences, seminars and the company website.

11. CONCLUSION

Based independent assessment on the baseline environmental status and also prediction of impacts the following conclusions are made by the EIA consulting organization and study team.

- This project will have beneficial effects in terms of growth and development of the regional economy
- This project will also generate direct and indirect employment to a considerable number of families, who will render their services for the employees of the project
- The proposed project is structured to be in line with the requirements of MoEF/CPCB/ PCB.
- Wastewater treatment facilities and high efficiency pollution abatement measures will result in minimising the adverse impacts on the environment

Thus, it can be concluded that with the judicious and proper implementation of the pollution control and mitigation measures, the proposed project can proceed without any significant negative impact on the environment.

12. DISCLOSURE OF CONSULTANTS

12.1. Introduction

The Environmental Impact Assessment (EIA) and Environment Management Plan (EMP) report has been prepared by carrying out various scientific studies. The studies have been carried out by M/s. Cholamandalam MS Risk Services Limited, Chennai, India.

The profiles of the Consultants are given below,

12.2. Cholamandalam MS Risk Services Limited – EIA Consultant

M/s Cholamandalam MS Risk Services Ltd (CMSRSL) is a joint venture between the Murugappa group, India and Mitsui Sumitomo Insurance Group, Japan. CMSRSL is an ISO 9001:2008 certified company. CMSRSL offers safety and environmental consulting services across Indian, Middle East and East Asian countries. CMSRL consists of six consulting domains such as environmental engineering and management, process safety, fire safety, electrical safety, construction safety and logistics risk assessment. CMSRSL is an NABET accredited EIA consulting organization for undertaking EIA studies in the following sectors: paper and pulp, thermal power plants, petroleum refineries, petrochemical complex, chemical fertilizers, synthetic organic chemical industries, ports and harbours and area development projects. CMSRSL has offered environmental and safety related consulting services for more than 5000 clients during last decade.

12.2.1. Details of Experts/Consultants Engaged for this EIA Study

Details of Experts/Consultants Engaged for this EIA Study

S.No.	Name	Role in the EIA Study
1	Mr V S Bhaskar	EIA Coordinator – Petroleum Refineries. Functional Area Expert(FAE) - Meteorology, Air Quality Modeling and Prediction Functional Area Expert (FAE) - Water Pollution Prevention, Control & Prediction of Impacts Functional Area Expert (FAE) - Noise / Vibration Functional Area Expert (FAE) – Risk & Hazards Management
2	Mr. D. Ravishankar	Functional Area Expert (FAE) - Air Pollution Prevention, Monitoring and Control

S.No.	Name	Role in the EIA Study
		Functional Area Expert FAE –Solid & Hazardous Waste Management
3	Mr.T.P.Natesan	Functional Area Expert (FAE) – Land Use, Hydrology, Ground Water & Water Conservation
4	Dr.T.Balakrishnan	Functional Area Expert (FAE) – Ecology and Biodiversity
5	Ms. Sathya. S	Functional Area Expert (FAE) – MSW and Team Member
6	Mr. C S Karthick	Functional Area Expert (FAE) – Socio-Economics
7	Mr.Ganta Srikanth	Associate Functional Area Expert (AFAE)- Water Pollution Prevention, Control & Prediction of Impacts and Air Pollution Prevention, Monitoring and Control

12.2.2. Other Technical Team Members

S.No.	Technical Members
1	Mr.Mahendra.B
2	Ms. Sujatha Gurudev

12.2.3. External Labs/Agencies involved in EIA Study

1	Base line Environmental data – Ambient air Quality, Water, Soil and Noise sampling & analysis.	Ind Research and Development House Pvt Ltd (IR&DH), Noida- NABL accredited and ISO 18000, ISO 9001 & ISO 14001 certified Lab)

12.2.4. NABET Certificate

National Accreditation Board for Education and Training
(A Member of International Accreditation Forum and Pacific Accreditation Cooperation)

NABET

QCI/NABET/ENV/ACO/16/12/0224 December 02, 2016

M/s Cholamandalam MS Risk Services
Dare House, IInd Floor, 2-NSC Bose Road,
Chennai- 600001
(Kind Attention: Sh. **Subbarao NV**)

Sub: Validity of Accreditation as EIA Consultant Organization – M/s Cholamandalam MS Risk Services

Dear Sir,

this has reference to the accreditation given to your organization and its validity under QC-NABET Scheme. The Accreditation of **M/s Cholamandalam MS Risk Services** is continued till their next assessment due in August, 2017.

The validity is subject to submission of required information documents related to above assessment to NABET on time.

You are requested not to use this letter after expiry of stated data.

With best regards,

A.K. Jha
Senior Director

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National Accreditation Board for Education & Training

Quality Council of India

CERTIFICATE OF ACCREDITATION

M/s Cholamandalam MS Risk Services (CMSRS)

Dare House, IInd Floor, 2-NSC Bose Road, Chennai - 600001

is hereby accorded accreditation under the QCI-NABET Scheme for Accreditation of EIA Consultant Organizations (Rev. 09, August 2011) for the following scope:

Sl.No.	Name of the Sector	Cat.
1.	Thermal Power Plants	A
2.	Cement plants	A
3.	Petroleum refining industry	A
4.	Chemical Fertilizers	A
5.	Synthetic organic chemicals industry (dyes & dye intermediates; bulk drugs and intermediates excluding drug formulations; synthetic rubbers; basic organic chemicals, other synthetic organic chemicals and chemical intermediates)	A
6.	Pulp & paper industry excluding manufacturing of paper from waste paper and manufacture of paper from ready pulp without bleaching	A
7.	Ports, harbours, jetties, marine terminals, break waters and dredging	A
8.	Building and large construction projects including shopping malls, multiplexes, commercial complexes, housing estates, hospitals, institutions	B

Name of approved EIA Coordinators & Functional Area Experts are given in minutes of AC Meeting dated Jan 17, Mar 28, Oct 15, Dec 10, 2014 and Jan 14, 2015 posted on QCI website

Accreditation to the above Sectors is subject to the EIA reports being prepared by the experts (EIA Coordinators & Functional Area Experts) mentioned in the above minutes and compliance to the Terms and Conditions of Accreditation.

Certificate No: NABET/ EIA/ 1316/ RA009

Valid up to: Nov. 27, 2016

C.E.O.

NABET

(Please refer http://nabet.qci.org.in/environment/ for latest status of accreditation)

Note

- Subject to continual compliance to NABET Scheme including Surveillance Assessment
- Updated status of accreditation available at www.qcin.org every 5th of the month