A Techno-Economic Study of Natural Gas Pipeline from Rajmundry to Mumbai

A Project Report submitted in partial fulfillment of the requirements for the Degree of

MASTER OF TECHNOLOGY

in

GAS ENGINEERING

(Academic Session **2003-05**)

By

GANGADHAR.S.GANACHARI

Under the Supervision of

Dr.B.P.PANDEY

COLLEGE OF ENGINEERING STUDIES
UNIVERSITY OF PETROLEUM & ENERGY STUDIES
DEHRADUN (U.A) 248007
May 2005

CERTIFICATE

This is to certify that the Project Report on *"A Techno-Economic Study of Natural Gas Pipeline from Rajmundry to Mumbai"* submitted to University of Petroleum & Energy Studies, Dehradun, by **Mr. Gangadhar S. Ganachari,** in partial fulfillment of the requirement for the award of Degree of Master of Technology in Gas Engineering (Academic Session 2003-05) is a bonafide work carried out by him under my supervision and guidance. This work has not been submitted anywhere else for any other degree or diploma.

Date: May 24, 05

Dr.B.P.Pandey

ACKNOWLEDGEMENT

This is to acknowledge with thanks the help, guidance and support that I have received during the Final Project.

My deep sense of gratitude to the management of University of Petroleum & Energy Studies, for giving me an opportunity to pursue my final project, and in particularly Dr.B.P.Pandey (Dean), for his valuable guidance and support.

My heart filled thanks to Dr.Himmat Singh (Distinguished professor) for his able co-Guidance.

My gratitude's to Dr.S.K.Chopra (Adivisor), Mr.V.B.kulkarni (Senior Project Manager), for their valuable support.

My loving prostration to my parents with out whose encouragement and guidance this project might not have seen the light of today.

Gangadhar.S.Ganachari
(M.Tech Gas Engineering)
University of Petroleum & Energy Studies
Bidholi
Dehradun

Date:

TABLE OF CONTENTS

Executive Summary

	Page No.
Chapter 1: PROJECT DESCRIPTION	01
1.1 General	01
1.2 Pipeline Design Throughput	01
Chapter 2 PIPELINE ROUTE SELECTION	02-20
2.1 Study of Relevant SOI Maps	02
2.2 Location of SV Stations	02
2.3 Route Selection Criteria	02
2.4` Procedure of Route Selection	03
2.5 Alignment Sheet	06
2.6 Location Classes for Design and Construction	09
2.7 Crossing Sheet	10
2.8 Pipeline Alignment	11
2.9 Remote Sensing & GIS for pipeline route selection	15
Chapter 3 DESIGN AND ASSUMPTIONS	21-32
3.1 Feasibility study	21
3.2 Pipeline Design Analysis	21
3.3 Pipeline Stability Analysis	27
3.4 Principle	27
3.5 Assumptions	29
3.6 Physical characteristics	31
3.7 Other Information	32
Chapter 4 BASIC ENGINEERING	33-45
4.1 Pipeline Construction Onshore	33

Chapter 5 PROJECT EXECUTION 46-51

5.1 stages 46
5.2 Project Management 50
5.3 Assumptions/Constraints in Project Execution 50

Chapter 6 PROCESS DESCRIPTION 52-73

6.1 General 52
6.2 System Requirements 54
6.3 Facilities 55
6.4 Utilities 62
6.5 Instrumentation/SCADA, Telecommunication and CP Systems 63

Chapter 7 COST ESTIMATION 74-82

7.1 Capital Cost Estimate 74
7.2 Indirect Costs 79
7.3 Contingencies 80
7.4 Financing Charges 80
7.5 Working Capital Margin 80
7.6 Exchange Rates 80
7.7 Township 81
7.8 Exclusions 81
7.9 Operating Cost Estimates 81
7.10 Pay Back Period 82

Chapter 8 EFFECT ON ENVIRONMENT 83-85

8.1 General 83
8.2 Impact on Topography 83
8.3 Air Pollution 84
8.4 Water Pollution 85
8.5 Line Leak/Burst 85

CONCLUSIONS & SUGGESTIONS FOR FUTURE WORK 86

REFERENCES 87

LIST OF TABLES: Page No (88-96)

TABLE 1: PIPELINE SELECTION, THROUGH PUT DESIGNED

TABLE 2: INFORMATION FROM CROSSING SHEET

TABLE 3: LONGITUDINAL JOINT FACTOR (E)

TABLE 4: TEMPERATURE DE-RATING FACTOR (T)

TABLE 5: DESIGN FACTOR (F)

TABLE 6: DETAILS OF PIPELINE

TABLE 7: CONSTRUCTION SURVEYING

TABLE 8: PIPELINE CROSSINGS

TABLE 9: TOTAL CAPITAL COST OF PIPELINE

TABLE 10: CAPITAL COST ESTIMATION OF DESPATCH TERMINAL (RAJMUNDRY) NG PIPELINE FOR RIL

TABLE 11: CAPITAL COST ESTIMATION OF INTERMEDIATE DESPATCH TERMINAL (AMRAVATI) NG PIPELINE

TABLE 12: CAPITAL COST ESTIMATION OF INTERMEDIATE DESPATCH TERMINAL (HYDERABAD) NG PIPELINE FOR RIL

TABLE 13: CAPITAL COST ESTIMATION OF INTERMEDIATE DESPATCH TERMINAL (PANDARPUR) NG PIPELINE FOR RIL

TABLE 14: CAPITAL COST ESTIMATION OF RECEVING TERMINAL (MUMBAI) NG PIPELINE FOR RIL

TABLE 15: CAPITAL COST OF NG PIPELINE (RIL)

TABLE 16: ANNUAL OPERATING COST

LIST OF FIGURES: Page No (95-101)

IMAGES OF REMOTE SENSING & GIS

LOCATION OF PIPELINE

PIPELINE ROUTE MAP

SOIL MAP OF AP AND MH

SOIL WATER HOLDING CAPACITY OF AP AND MH

PIPELINE ROUTE BASED ON CLASSIFICATION OF AREA (CLASS A, B, C, D)

Executive summary

1 Back ground

The demand for natural gas as feed for power plant & fertilizer in the northern, central and western regions is presently being met from indigenous NG production from ONGC, LNG import.

However, supply-demand statistics projected for years beyond 2006 07 by OCC have indicated a deficit in the, western region, Northern region. Increasing demand for NG product has put a tremendous pressure on pipeline network.

Accordingly requirement for a NG pipeline starting from Rajmundry/Hyderabad/Solapur/Pune/Mumbai has been identified to facilitate transportation of natural gas from East Godavari basin.

The NG pipeline project has been envisaged based on techno economic study on transportation of NG by Pipeline.

2 Project Requirement and Facilities

It is proposed to lay about 1105 KM long NG pipeline from Rajmundry / Amaravati / Hyderabad / Solapur / Pandarpur / Pune / Mumbai with tap-off points at required place's.

The pipeline will be supplied natural gas from East Godavari basin. NG will be delivered. In-between, four compressor stations are envisaged to meet the NG transportation of 30MMSCMD through pipeline. Storage and marketing/distribution facilities at the tap-off locations, viz., at required stage are outside the scope of this project.

RIL is teeing up with NG marketing companies for supply and distribution of NG.RIL would enter MOUs with them.

The proposed pipeline system has been sized after techno- economic study based on the quantities given by RIL (according to data collected through industry & web site). As per indication given recently by RIL/OCC, the pipeline may be required to transport increased quantities of NG in future. This future requirement of increased pipeline throughput may be feasible by augmenting the compressor station facilities/ pipeline looping.

3 Basis of DR

For preparation of the DR, only preliminary design and engineering could be carried out on the basis of desk top study of the SOI topographic maps and certain assumptions in absence of data at this stage.

4 Cost Estimates

For the selected route, the techno-economic study was carried out and pipeline of 44" dia size has been selected for minor section (Rajmundry to Hyderabad) of the pipeline. Other section is 36"(from Hyderabad to Mumbai) (these data is collected from industry & web site).

The Capital Cost for the NG pipeline project is estimated at RS. 3956.01crores. The annual operating cost is estimated at Rs. 5807 crores.The pay back period for the project is approximately 10.25years

5 Environment Impact

A separate Environment Impact Assessment (EIA) study is being carried to assess the impact on environment. The NG pipeline will have negligible impact on the topography of the intervening terrain all along the pipeline alignment.

6 Project Benefits

NG is a clean, convenient and environment-friendly fuel being utilized largely in, both, the domestic sector as well as the industrial/commercial sectors. Its use provides social benefits which go a long way in improving the quality of life within the vicinity where

NG is replacing the other polluting fuels. The transportation of LPG through the pipeline will have distinct advantages vis-a-vis its transportation by alternative modes of transportation presently in use.
Some of the major benefits of this project are given below:

- Pipeline, being underground, will provide lesser direct contact with the populace there by reducing its hazardous impact as well as provide better overall security.

- Availability of the highways/railways for transporting other materials/goods will improve.

- Uninterrupted supply of NG will be ensured as compared to the otherwise intermittent and discrete supplies resulting from traffic congestion, non-availability /shortage of road/rail tankers and other infrastructures being currently faced in case of rail and road transportation.

- The unit rate of transportation of LPG by pipeline being least among other modes of transportation (road), the project would result in appreciable saving in the NG delivered cost.

CHAPTER -1

Project Description

1.1 General

It is proposed to lay about 1105 KM long NG pipeline from Rajmundry / Amaravati / Hyderabad / Solapur / Pandarpur / Pune / Mumbai with tap-off points at required place's. The pipeline will be supplied natural gas from East Godavari basin. NG will be delivered. In-between, four compressor stations are envisaged to meet the NG transportation of 30MMSCMD through pipeline. Storage and marketing/distribution facilities at the tap-off locations, viz., at required stage are outside the scope of this project.RIL is teeing up with NG marketing companies for supply and distribution of NG.RIL would enter MOUs with them.

The proposed pipeline system has been sized after techno- economic study based on the quantities given by RIL (according to data collected through industry & web site). As per indication given recently by RIL/OCC, the pipeline may be required to transport increased quantities of NG in future. This future requirement of increased pipeline throughput may be feasible by augmenting the compressor station facilities/ pipeline looping.

1.2 Pipeline Design Throughput

Pipeline design throughput will be based on the annual production & demand projections of various power sector ,fertilizer, domestic usage units located in the regions along pipeline .This is based on overall NG production in East Godavari basin ,demand in western, central region envisaged as 30MMSCMD.for first phase and increase capacity according to demand.

Pipeline will be designed for the final throughput as envisaged for Phase I and given in Table 3.1. Compressing system will be designed for the throughput as envisaged for Phase-I with a provision for augmenting the same for future at a later date.

TABLE - 1

S.NO.	PIPELINE SECTION	PIPELINE DESIGN THROUGHPUT (MMSCMD)
1.	Rajmundry to Amravati	30
2	Amravati to Hyderabad	30
3	Hyderabad to Pandarpur	30
4.	Pandarpur to Mumbai	30

CHAPTER-2
Pipeline Route Selection

2.1 Study of Relevant SOI Maps

Relevant Survey of India (SOI) topographical maps were referred for the preliminary study of route alternatives.

2.2 Location of SV Stations

SV Stations are proposed to have remote operated station block valves. In accordance with the applicable code for NG pipeline, provision has been made for SV station at every 12 KM of the proposed pipeline alignment.

2.3 Route Selection Criteria

Preliminary study of alternative routes was carried out on SOI topographical sheets (Scale 1,000,000, 1:250,000) and 1:50,000).

Following important factors were kept in mind while selecting the pipeline route .

1. Shortest possible length,
2. Minimum rail, Road, River, Nala and stream Crossings,
3. Availability of Right-of-Way (ROW)and future development plan,
4. Easy access to the route during construction , maintenance and operation,
5. Favorable ground profile and hydraulic gradients, Avoiding / minimizing rocky, marshy and cultivated areas,
6. Avoiding forest ,mining and military areas and other sensitive zones
7. Minimising number of bends,
8. Safety of people ,environment ,property and maintenance of ecological balance,
9. Availability of infrastructural facilities, e. g., land, electric power, water, etc., for SV stations, intermediate booster stations, etc.

2.4 Procedure of Route Selection

Route selection process of identifying constraints, avoiding undesirable areas and maintaining the economic feasibility of pipeline. The ideal route of course would a straight line from the origin to the terminal point. The preliminary route selection involves planning the route on available maps in office. Then followed by fieldwork to verify the acceptability of the route. The following factors must be considered prior to selecting the optimal route for the pipeline:

- Cost efficiency
- Pipeline integrity
- Environmental impacts
- Public safety
- Land-use contracts
- Restricted proximity to existing facilities

2.4.1 Key factors for route selection

- Related to rivers, creeks, lakes and swamps
    - Unnecessary crossings
    - Braided channels
    - Areas of erosion potential
    - Bedrock
    - Natural meander progression

- Related to physiography
    - Excessively steep slope
    - Side slope

- Rocky slope
- Erosive soils
- Rocky soil
- Sandy soil
- Earthquake location
- Fault location

- Related to environment
  - Fish spawning areas
  - Historical & archaeological sites
  - Merchantable timberland
- Others factors that affect the route selection are
  - Road and railway crossings
  - Areas of population concentration
  - Restricted areas such as national parks
  - Forest regeneration sites. Etc.

2.4.2 Map selection

- Obtain the best available topographic maps
- Use scale of 1:50000 if possible
- Well site and pipeline plans are obtained from the appropriate Regulatory Department. Etc.

2.4.3 Plotting restriction

- Major highways and roads
- Townships
- Railways
- Rivers, canals etc.
- Well sites and access roads
- Existing pipelines

- Wildlife and environmental reserves
- Parks
- Historical reserves
- Forest reserve sites

2.4.4 Establishing a Route

- Draw a line form point A to B.
- Draw alternate route
- Draft preliminary route sketch
- Finding out the minimum length route.

2.4.5 Evaluating the preliminary route

- Note the river or major creeks crossing
- Check the proximity to population concentration and restricted areas
- Take initial environmental consideration into account complete an initial environmental consideration into account
- Complete an initial terrain analysis
- Establish the preliminary length of the route

2.4.6 Refining the preliminary Route

- Evaluate the various consideration/ restrictions for each alternate route or option.
- Redraw or refine the route
- Re-evaluate each route and choose the most optimum solution from a cost perspective.

2.4.7 Obtain existing Aerial Photograph

- Obtain suitable photograph from government photo libraries.
- Evaluate river crossing and steep terrain.
- When existing government photos are outdated, the proposed route may be re-flown and re-photographed, if the project is large enough to warrant it.

2.4.8 Flying the preliminary route

- Confirm or reject speculations
- Reconsider any alternate routes
- Adjust the lines as necessary and add any pertinent notes.

After that finalizing of the route (Office route) is done.

2.5 Alignment Sheet

Alignment sheets provide information about topography and ground profile of the pipeline. These alignment sheets are then forwarded to the contractor providing all the technical details for carrying out pipeline installation.

An alignment sheet consists of several rows in which the following parameters present:

- Intersection points (TP/IP): TP refers to Turning points namely TP-0, TP-1, TP-2 etc. and IP refers to intermediate points namely IP-1, IP-2, IP-3 etc. these intermediate points are used for distinguishing line.
- Deflection angle: This is the angle at which the route is deflected from its original path.
- Distance between IP/TP in meters

- State district and Tehsil
- Planimetry: The complete scaled route with various topographical details, their location and orientation is given. For e.g., road crossings, Nala crossings, rail crossings etc.

The scale is used as follows:

1. Horizontally 1:50000
2. Vertically 1:10000

- Ground profile: It is drawn with the above scale. Datum level is considered to be some meters above mean sea level for easy reference.
- Surface terrain details: The types of terrains encountered in the path of the line like fields, road, rivers etc.
- Special provision: these are the provisions like concrete coating to counterattack the effect of buoyancy.
- Class/Zone: Different classes are specified such as class-1, class-2 etc. these classes are specified according to the ASME 31.8 for gas pipeline and 31.4 for oil pipeline.
- Design factor: respective design factors of the classes are specified as per ASME 31.8 for gas pipeline and 31.4 for oil pipeline.

- Cumulative design: the row limits of all major facilities are specified.
- Pipeline cover minimum: Pipeline is buried at a depth of 1.0 m except at river/road/rail crossings. The minimum cover of all the facilities is marked by extension lines above the crossings. The minimum cover for the road crossings is 1.2 m and that of rail is 1.7 m.
- Special installations fitting markers: KM is used after every kilometer. Direction marker is indicated before a pipe undergoes a

bend. Pipeline warning sign is used before any crossings Arial marker is indicated after every 5 km.

- Pipe wall thickness: the thickness of the pipe varies according to the classes. Different classes will have different design factors with which the thickness also varies. This is done according to specifications as per ASME 31.8 for gas pipeline and 31.4 for oil pipeline.
- Crossings: symbols of various crossings are used to indicate the type of crossing including the method of installation of pipeline across the crossing.
- Coating scheme: the coating scheme is 3-layer side extended polyethylene coating.
- Cathodic protection installation.
- Soil resistivity
- Soil stratification

2.5.2 Legends use in the alignment sheets is:

- Topographical symbols used in the sheets are given
- Pipeline symbols used in the sheets are given
- Soil symbols used in the sheets are given
- General notes.
- Bill of material for drawing
- Reference drawings: the cross section drawing numbers are mentioned which have to be referred for the details of various facilities.
- Bottom most right part consists of the name of the client, project, section, chain age, job number and the drawing number.

2.6 Location Classes For Design And Construction

2.6.1 Location class 1 A

Class 1 is any 1 – mile section that has 10 or fewer buildings intended for human occupancy. A location class 1 is intended to reflect areas such as wasteland, deserts, mountains, grazing land, farmland and sparsely populated area.

2.6.2 Class (1) division 1

This division is a location class 1 where the design factor of the pipe is greater than 0.72 but equal to or less than 0.80 and has been hydrostatically tested to 1.25 times than the maximum operating pressure.

2.6.3 Class (1) division 2

This division is a location class 1 where the design factor is equal to or less than 0.72 and has been tested to 1.1 times the maximum operating pressure.

2.6.4 Location class 2

A location class 2 is any 1-mile section that has more than 10 but fewer than 46 buildings intended for human occupancy. A location class 2 is intended to reflect areas where the degree of population is intermediate between location class 1 and location class 3 such as fringe areas around cities and towns, industrial areas, ranch or country estates etc.

2.6.5 Location class 3

A location class 3 is any 1-mile section that has 46 or more buildings intended for human occupancy except when a location class 4 prevails. A location class 3 is

intended to reflect areas such as suburban housing development, shopping centers, residential areas industrial areas and other populated areas not meeting location class 4 requirements.

2.6.6 Location class 4.

A location class 4 includes areas multistory buildings are prevalent where traffic is heavy or dense and where there may be numerous other utilities underground. Multistory means four or ground floor. The depth of basement s or number of basement floors is immaterial.

2.7 Crossing Sheet

Crossing sheet provides the information about no. Of crossing takes place across the proposed pipeline route and their location of the class.

2.7.1 Information from crossing sheet (TABLE -2)

Pipeline section
Length in Km
Highest elevation in m
Number of major crossings
Railways crossings
National highway crossings
State highway crossings
Road crossings
Major/Minor River Crossings
Nala/ Stream/ Canal Crossings

2.7.2 Crossing Details

- ***River crossings:*** All river crossings shall have a minimum cover of 2.5 m below scour level or as per requirements of local/statutory authorities, whichever is higher. Crossings shall be carried out by open cut or Horizontal Directional Drilling (HDD) method depending upon width, depth, bank slopes, soil type, flow etc.

- ***Rail crossings:*** Pipeline at rail crossings shall be provided with casing pipe. The casing pipe shall be two nominal pipe sizes larger than carrier pipe and shall be installed by Boring/Jacking. The rail crossing shall comply with the requirements of API 1102.

- ***Road crossings:*** Road crossings shall comply with the requirements of API 1102. All national highways crossing shall be cased crossing. The casing pipe shall be two nominal pipe sizes larger than carrier pipe. The casing pipe shall be installed by Boring/Jacking method. Higher thickness carrier pipes shall be used at crossing.

- ***Existing pipeline crossing:*** The specific requirements of Owner/operator of existing pipeline shall generally be followed. The minimum clearance between the lines shall be 300 mm unless specified otherwise.

2.8 Pipeline Alignment

2.8.1 Rajmundry to Amravati,

The proposed pipeline alignment wi11 pass through the State of Andhra Pradesh, Karnataka and Maharastra. The length of this section will be approximately, 1105KM.The proposed pipeline will pass near to the towns of, near by Amravati Bidar, Solapur, Gulbarga, etc. enroute, from Rajmundry To Mumbai, the pipeline

will cross the Krishna River. The pipeline alignment will, generally, pass through normal terrain and agricultural land. However, undulating and hilly terrain will be encountered where the pipeline route runs in the vicinity of Range near the towns of Abu Road and Beware. The area, through which the pipeline will traverse, is criss-crossed with a large number of naahs, streams, salt basin and rivers. A majority of these streams and rivers are seasonal in nature and water flow occurs during the monsoon months. It is proposed to have Despatch Terminal at Rajmundry. The approximate number of major crossings falling enroute are as follows:

- Rail crossing - 5 Nos.
- Road crossing - 12 Nos.
- Minor water crossing - 4 Nos.

2.8.2 Amravati to Hyderabad on the Rajmundry – Mumbai pipeline

The total length of this sections is, approximately, 227 KM. The proposed pipeline alignment will follow the route up to its crossing with the river and then it will divert from the route and will pass near to the towns of Pengod, Tipparti, Nalgouda, Maisrametc. Installation of pipeline across the rivers is envisaged to be carried out by horizontal directional drilling method. The terrain through which the pipeline alignment passes is, generally assumed, flat/agricultural land. The area through which the pipeline traverses is criss-crossed with a large number of nallahs, streams, salt basins and rivers. A majority of these streams and rivers are seasonal in nature and water flow occurs during the monsoon months. It is proposed to have despatch terminals at Amravati to Hyderabad in this section. The approximate number of major crossings falling enroute areas follows:

- Rail crossing - 7 Nos
- Road crossing - 1 Nos
- River crossing - 1 Nos

2.8.3 Hyderabad to Pandarpur Pipeline

The total length of this section will be, approximately, 356 KM. The proposed pipeline alignment will pass near to the towns of Alur, Miryam Hurruk, nerono, akalkot, Mangalwedhaa, Solapur etc., on its way to, Pandarpur where it will join the proposed pipeline section. The terrain through which the pipeline alignment will pass is, generally, normal terrain and agricultural land. The area through which the pipeline will traverse is criss-crossed with a large number of nallahs, streams, salt basin and rivers. A majority of these streams and rivers are seasonal in nature and water flow occurs during the monsoon months. It is proposed to have despatch terminals at Hyderabad and in this section. The approximate number of major crossings falling enroute are as follows:

- Rail crossing - 3 Nos
- Road crossing - 23 Nos
- River crossing - 0 Nos

2.8.4 Pandarpur to Mumbai Pipeline

The total length of this section will be, approximately, 356 KM. The proposed pipeline alignment will pass near to the towns of saswad, pune, lunawala, etc., on its way to, Mumbai where it will join the proposed pipeline section. The terrain through which the pipeline alignment will pass is, generally, normal terrain and agricultural land. The area through which the pipeline will traverse is criss-crossed with a large number of nallahs, streams, salt basin and rivers. A majority of these streams and rivers are seasonal in nature and water flow occurs during the monsoon months. It is proposed to have receiving terminals at Mumbai and in this section. The approximate number of major crossings falling enroute are as follows:

- Rail crossing - 5 Nos
- Road crossing - 19 Nos

- River crossing - 3 Nos

2.9 USE OF REMOTE SENSING & GIS FOR PIPELINE ROUTE SELECTION

2.9.1 General

Scientific planning of pipeline route can reduce cost and time of project execution and hence the operating expenses. Pipeline alignment is basically an optimization between costs of the material and the construction. Natural and man-made terrain obstructions cause spatial variation in construction cost due to changing thematic features like types of soils, intervals of slope, etc. Manual pipeline route planning uses available maps, surveys and experience and is seriously constrained due to lack of updated data and quantitative approach. This is accentuated for complex terrains and long routes. Remote sensing (RS) and GIS method on the contrary uses updated maps from latest RS data, integrates thematic cost layers in GIS environment and computes all possible routes with associated costs. Apart from saving 5-15 % route length, the method has potential benefits like cadastral overlays on route for gadget notification, precise location data on installations and organization of O&M (Operations and Maintenance data).

2.9.2 Data Used

In India satellite remote sensing has significantly contributed to the development activities related to planning and monitoring of various resources and projects. In conjunction with the study area various maps has been developed to facilitate for the design of the pipeline alignment.

The maps on various resources such as landuse/landcover, soil etc were prepared using the visual interpretation techniques and from the survey of India (SOI) Toposheets. The resources considered for the study area are briefly described in the following paragraphs.

2.9.3 Landuse/Landcover Map

Of all the factors that determine the quality of our environment, the most fundamental is the way how we make use of land. Existing information on the Landuse and Landcover is the pre requisite for the planning strategies of the future development activities for any area. In the present context the information on the landuse and landcover plays a major role in the pipeline alignment.

The landuse and landcover map include the categories such as forest land, Kharif crops, Rabi crops, double cropped area, land with scrub and without scrub etc.

The spatial distribution of these categories is shown in the map entitled Landuse/Landcover Map.

2.9.4 Soil Map

A semi detailed soil map was prepared with limited field checks and sample analysis data. The thematic map details were transferred on the base map. The table ..... Shows the various soils based on the texture of the soil.

2.9.5 Soil water holding capacity Map

This map is prepared based on the porosity of the soil. The soil texture is taken into consideration along with the cohesive nature of the soils.

2.9.6 Generation of the Digital Resource Map

Visually interpreted maps of all the themes covering the study area are collected in the paper format. Each resource map is then scanned. The features scanned in the form of the square size grid cells numbered in terms of rows and columns. The resulting data of the scanner is in the form of the raster format. The raster form

maps are then converted into vector form using the raster to vector conversion software. (R2V). These resource maps are then edited/corrected. All these resource maps are then brought in Arc/Info GIS package.

The features of all the coverages thus created have the digitizer coordinate as their coordinates. In order to bring them to real world coordinates these coverages are transformed using the Project and Transform Command available in GIS software.

Topology is established among various features of each coverage of all these using a set of commands (clean/Build) available in GIS package. The various stages involved while building topology using clean command are given below.

i) Linking chains into boundatry network
ii) Check of closure
iii) Link areas to form polygons
iv) Compute polygon areas
v) Associate non-graphic attribute to polygons.

2.9.7 Land Irrigability Classification

Water is one of the most important input to raise productivity and hence considerable important has been given to the development and extension of irrigation. Management of irrigation water and ensuring its economical and efficient use has been a problem since inception of irrigation. For want of drainage, soils are turning salt affected/ problematic all over the country.

The interaction of soils and land condition for irrigation is concerned primarily with predicting the behavior of soils under the greatly altered water regime brought by irrigation.

To carry out land irrigability classification of command areas, special interpretation technique and classification of soils for sustained use under

irrigation are often required. The classification developed by US Department of Agriculture is based on effective soil depth, soil texture, soil permeability, coarse fragments etc. The soils are grouped into soil irrigability classes according to their limitations for sustained use under irrigation regardless of their location or size of the individual mapping unit. Further soil irrigibality classes are classified into land irrigability classes considering topography, drainage, slope etc.

2.9.8 Soil Irrigability Classes

According to suitability of soils for sustained use under irrigation, they are grouped into different soil irrigability classes. This grouping is carried out without taking into consideration the available quantity or quality of water lands development costs, drainage facilities etc.

Table: Soil irrigability classes and their definitions.

CLASS	DEFINITIONS
A	None to slight limitations for sustained use under Irrigation.
B	Moderate soil limitations for sustained use Under Irrigation.
C	Severe soil limitations for sustained use under Irrigation.
D	Very severe soil limitations for sustained use under irrigation.
E	Not suited for irrigation.

2.9.9 Land irrigability Classes

The suitability of land for irrigation depends on physical factors like quality of irrigation water and socio-economic factors like land development costs. Provision of drainage facilities, production costs of individual crops.

CLASS DEFINITIONS

Class 1 Lands that have few limitations of soils, topography or drainage for sustained use under irrigation

Class 2 Lands that have moderate limitations of soils, topography or drainage for sustained use under irrigation.

Class 3 Lands that have severe limitations of soils, topography or drainage for sustained use under irrigation.

Class 4 Lands that are marginal for sustained use under irrigation because of very severe limitations of either soil topography or drainage

Class 5 Lands that have temporarily closed as not suitable for sustained use under irrigation.

Class 6 Lands not suited for sustained use under irrigation

Soil permeability as a criteria is not applicable to deep black soils because of their unique properties.

Deep black soils (Vertisols) which are inherently slowly permeable due to expanding 2:1 lattice type minerals do not qualify for irrigability soil class A. They would qualify for being placed in B,C, and D classes depending upon their limitations.

2.9.10 Database design and organization in GIS

The most important and complex tasks upon which the usefulness of GIS depends are designing, organizing and creating an error free digital database. So utmost care is taken while the database is designed for the layers specified.

All the features of the each resources map are digitized and labeled with unique identifier. Thus all the resource maps as well as the base maps are converted into a set of digital data layers. These layers are corrected by editing line dangles, label errors of polygon etc caused during the process of digitization. Topology is built for all the features using the commands from the GIS Packages. All the data layers are transformed into a real world coordinates systems in which the features of each data layers are identified with ground coordinates.

2.9.11 Benefits: summing up

The method for semi-automated alignment of pipelines using RS and GIS tools has unique advantages like

- Updated and integrated information on terrain,
- Shortest route by automated and computation based search techniques,
- Spatial and numerical data organization of layout,
- Cadastral overlays for route ROU/ROW measures,
- Cost well compensated by high benefits and speedy implementation and
- Downstream options for O&M support.

The method is general enough to be applicable for other sectors related to linear infrastructure planning like alignment of electric transmission lines, network plans for roads and rail etc.

CHAPTER-3
Design Basis and Assumption

3.0 Onshore Pipeline Designing

3.1 Feasibility study

Before designing the pipeline feasibility studies has to be done. After getting the inputs from the clients feasibility analysis has to be done by the organization. If the proposed pipeline is feasible to lay down then engineering design basis is done.

Inputs from the clients are:

- Locations of the pipeline
- Various consumers of the product
- Flow rate of product

3.2 Pipeline Design Analysis

3.2.1 Wall Thickness Calculation

Formulation for pipe wall thickness and grade selection based on pressure and other loads, the wall thickness of gas transmission pipeline varies with the pipe grade, location and design pressure. The design pressure, which is specified by the system designer for any, should not be less than the maximum operating pressure (MOP) of the pipeline at the location where all the forces are considered. The pipe wall thickness and material selected by the designer should provide adequate strength to prevent deformation and collapse by handling stresses, external reaction, thermal expansions and contractions.

According to the pipeline codes ANSI-ASME B31.8, the stress design requirement to be considered are limited to normal design conditions for operating pressure, thermal expansion and contraction ranges, temperature differential, and other forces acting on the pipeline. Additional loading include:

- Occasional extreme loads (Earthquake)
- Slope Movements
- Fault Movements
- Seismic-related earth movements
- Loss of support
- Thaw settlements
- Frost heave
- Cylindrical traffic load
- Construction and maintenance deformation
- Mechanical vibrations
- Hydraulic Shock

These loadings require supplemental design criteria (Such as heavier wall thickness or stronger material) to ensure a safe and operational pipeline.
This report covers the calculation of pipeline wall thickness as per ASME Code B 31.8, for onshore gas pipelines.

3.2.2 Codes and Standards

Pipeline and associated facilities shall be designed and engineered primarily in accordance with the provisions of the latest edition of code ASME B 31.8 (Gas Transmission and Distribution Piping Systems) and OISD 141 (Design and Construction Requirement for Cross Country Hydrocarbon Pipelines). In addition following codes/standards shall also be applicable.

OISD 138: Inspection of Cross Country Pipelines-Onshore.

ASME B 31.3: Chemical Plant and Petroleum Refinery Piping.

API RP 1102: Steel Pipelines Crossing Railways & Highways.

API Std. 1104: Standard for Welding Pipelines and Related Facilities.

Petroleum Rules:Part V; Transport by Pipelines

The following codes and standards form the basis of the pipelines wall thickness calculations.

American Petroleum Institute (API)

API 5LSpecification for Line Pipe

American Society of Mechanical Engineers (ASME)

ASME B 31.8 Gas Transmissions and Distribution Piping System Pipeline for Pressure Piping

3.2.3 Formula used

The design pressure for steel gas piping systems or the nominal wall thickness for a given piping system or the nominal wall thickness for a given design pressure shall be determined by the formula

$$t = \frac{PD}{2SFET}$$

Where,

P = design pressure in psi

S = specified minimum yield strength in psi

t = nominal wall thickness, in mm

D = pipe outside diameter, in mm

F = design factor

E = Longitudinal joint factor

T = temperature derating factor.

Design pressure (P)

It is the maximum pressure permitted by this code, as determined by the design procedures applicable to the materials and locations involved.

Nominal wall thickness (t)

It is the wall thickness computed by or used in the design equation. Under this code, pipe may be ordered to this computed wall thickness without adding allowance to compensate for the under thickness tolerance permitted in approved specification.

Specified minimum yield strength (S)

It is expressed in pound per square inch, is the minimum yield strength prescribed by the specification under which pipe is purchased from the manufacturer.

Diameter or Nominal outside diameter (D)

It is the as produced or as-specified outside diameter of the pipe, not to be confused with dimensionless NPS. For example,

NPS 12 pipe has a specified outside diameter of 12.750 in.
NPS 8 pipe has a specified outside diameter of 8.625 in.
NPS 24 pipe has a specified outside diameter of 24.000in.

Longitudinal Joint Factor (E)

If the type of longitudinal joint can be determined with certainty, the corresponding longitudinal joint factor, E may be used. Other wise, E shall be taken as .60 for NPS4 and smaller, or .80 for pipe larger than NPS4

TABLE – 3.4.5.

Spec. No.	Pipe class	E factor
ASTM A 53	Seam Less	1.00
	Electric resistance welding	1.00
	Furnace Butt welded: continuous weld	0.60
ASTM A 106	Seamless	1.00
ASTM A 134	Electric Fusion Arc Welded	0.8
ASTM A 135	Electric resistance welded	1.00
ASTM A 139	Electric Fusion welded	0.8
ASTM A 211	Spiral welded steel pipe	0.8
ASTM A 333	Seamless	1.00
	Electric resistance welding	1.00
ASTM A 381	Double submerged arc welding	1.00
ASTM A 671	Electric fusion welded	
	Classes 13,23,33,43,53	0.80
	Classes 12,22,32,42,52	1.00
ASTM A 672	Electric fusion welded	
	Classes 13,23,33,43,53	0.80
	Classes 12,22,32,42,52	1.00
API 5L	Seamless	1.00
	Electric resistance welding	1.00
	Electric flash welded	1.00
	Submerged arc welded	1.00
	Furnace butt welded	0.60

Temperature De-rating factor (T)

Temperature, °F	Temperature Derating Factor, T
250 or less	1.000
300	0.967
350	0.933
400	0.900
450	0.867

Design factor (F)

Location class	Design Factor
Location class 1, division 1	0.80
Location class 1, division 2	0.72
Location class 2	0.60
Location class 3	0.50
Location class 4	0.40

The next available wall thickness as per API 5L greater than the calculated thickness is then selected.

The minimum acceptable wall thickness is taken as 6.4 mm to prevent damage from handling of pipes during transportation and construction phases. The highest grade selected is API 5L Gr. X-65, PSL-2.

In order to identify the most economical option from the numerous material, wall thickness combinations, the total tonnage for each combination for the given pipeline length is determined. The benefits of reduced tonnage (by the selection of higher grade material) are compared to incremental cost associated with selection of superior metallurgy.

Through the above process the optimum material and wall thickness combination is identified. The wall thickness selected for the proposed pipelines are summarized in Table-1

Table- 6

Specified minimum yield strength (S)	= 46000 psi
Design pressure (P)	= 92 (kg/cm^2
Density	= 7850 (kg/m^3)
Steel Grade	= X46

(Dia) (in)	F	E	T	Thickness (mm)	Available thickness (mm)	L (Km)	Weight of steel (Kg)	Weight of steel (MT)
42	0.72	1	1	21.0	22.20	400	228665168913.02	228.67
42	0.6	1	1	25.2	25.40	150	97808929154.93	97.81
42	0.5	1	1	30.2	30.20	50	38585353509.65	38.59
42	0.4	1	1	37.8		12	0.00	0.00

3.3 Pipeline Stability Analysis

This section covers the anti-buoyancy measures to be provided at water crossing, marshy and water logged areas along the pipeline route. The continuous concrete coating has been considered for anti buoyancy measures.

This covers the anti buoyancy measures to be provided at water crossing, water logged areas along the pipeline route. The continuous concrete coating has been considered for anti buoyancy measures.

Pipelines are subjected to buoyant forces when they encounter freestanding or flowing water and when buried in saturated soils. The buoyant forces are counteracted by the addition of weight such as swamp weights, river weights or continuous concrete coating.

The selection of buoyancy control measure depends onsite specific basis. For e.g., Swamp weights are good for wet areas where the stays close to the bottom of the ditch. If the ditch is filled with water, a river weight or concrete coating may be required to keep the pipe stable. The choice of the two is based on its economic.

3.4 Principle

The required amount of weight is calculated by equating the forces due to mass of the pipe and weights with the buoyancy factor are considered to ensure the pipe will stay down. Continuous concrete coating consists of a coating that completely surrounds the pipe. It provides excellent mechanical protection for the pipeline particularly in fast flowing water or in rocky areas.

The concrete is usually applied by forming and pouring. The coating may be applied either at central batching plant or specific field site depending upon the availability of materials and transportation costs.

Some of the other methods used to apply the concrete to the pipe include uniting, where the concrete is manually sprayed on pipe; impingement, where the concrete is sprayed on pipe as it is rotated; extrusion, where the concrete is applied on pipe while passing through machine.

The inputs for the Analysis are

- Pipeline Diameter
- Pipeline Wall Thickness
- Pipeline Coating (3LPE /CoalTar Enamel/ 3LPP/FBE)
- Coating Density
- Concrete Density
- Steel Density
- Water Density
- Pipeline Material
- Factor of Safety

Note: This floatation check has been carried out for pipeline in the empty condition

3.4.1 Formulae used

Pipeline weight in Kg/Meter (W_1) = $3.14(D-t_p).t_p.\rho_s$

Coating Weight in Kg/Meter (W_2) = $0.758[(D+2t_{pp})^2-(D)^2].\rho_{pp}$

Concrete Weight in Kg/Meter (W_3) = $0.758[(D+2t_{pp}+2t_{cc})^2-(D+2t_{pp})^2].\rho_{cc}$

Buoyancy force (B)= $0.758(D+2tpp+2tcc)^2$. ρw

Factor of safety (FOS).B = W1+ W2+W3>1.3

$W_p = W_1 + W_2 + W_3$

Where:

t_p = thickness of pipe in mm.
D = Diameter of pipe in mm.
t_{pp} = Thickness of PE coating in mm.
t_{cc} = Thickness of Concrete coating in mm.
ρ_s = Density of steel.
ρ_{pp} = Density of Coating.
$\rho\rho_{cc}$ = Density of Concrete.
W_p = Net weight of pipe including coatings
W_1 = Steel pipe weight.
W_2 = PE coating weight.
W_3 = Concrete Coating weight.

3.5 Assumptions

i) Product natural gas to be (major portion is methane) transported and its physical Pressurised gas under characteristics conditions of transportation

ii) Permissible Contamination Traces of water

iii) Compressing stream Hours 8000 Hours/Yr

iv) Economic design life of pipeline 35 years

V) Design Temperature	
- Above-ground:	20 to 65°C
- Sub-soil:	20.to 0°C
vi) Diameter of pipeline	1)44" from Rajmundry to Amravati Amravati to Hyderabad 2) 36" from Hyderabad to Pandarpur Pandarpur to Mumbai
vii) Pipeline operating pressure	200bar ($kg/cm^{2)}$
IX) Thickness of pipeline	6.375 mm
X) Grade of pipeline	X65;HS
XI) Kilometer of Pipeline	1269 KM
XII) Throughput of NG through Pipeline	30MMSCMD
XIII) Compressor station along pipeline	4 stations

3.6 Physical characteristics (Table 7)

Composition	
Component	**Mole %**
N2	0.38
CO2	0.10
H2S	0.00
CH4	**98.76**
C2H6	0.44
C3H8	0.21
iC4H10	0.05
nC4H10	0.04
iC5H12	0.02
nC5H12	0.00
Pseudo C6	0.00
C7+	0.00
Total	**100.00**
Molar mass	**16.29**

Molar mass	**Seperator gas lbm/mol**	**g/mol**
C7+	0.2416	109.59
Fluid	0.0357	16.18
Density	**g/cm3**	**kg/m3**
Fluid	0.000683	0.683
Relative density	0.559	

The utilities like power, raw water, fire water" instrument air will be made available at the battery limit of the despatch terminal to meet the requirements of the project. As part of power supply system for the SV,CP and Repeater Stations and the pipeline facilities at the tap-off stations, provision has been made to include necessary feeder cable, step-down facilities, switchgear, etc. For intermediate booster stations located in remote areas, diesel drive has been

envisaged at this stage. Possibility of utilising grid power for these intermediate compressor station corporated doing implementation stage.

3.7 Other Information

For the purpose of carrying out the study, the following assumptions have been made in consultation with RIL:

i) Requirement of electric power at the dispatch terminals shall be met from the existing power supply facilities, and, no standby facility has been considered.

ii) An impressed current cathodic protection system has been considered for the protection of underground pipeline from corrosion.

iii) An optical fiber communication system has been considered for the efficient and reliable operation of the system.

iv)For efficient, reliable and smooth operation of the pipeline system, centralised SCADA control centre proposed to be located at Mumbai with provision of remote operation of sectionalizing valves has been envisaged. For leak detection along the pipeline route, the negative pressure wave detection software will employ acoustic detectors coinciding with the remote terminal unit (RTU) location provided at the despatch terminals, intermediate pumping stations and SV-cum-CP the stations, and, at the NG tap-off stations.

v) At this stage, for remote located booster stations,. Diesel based power generation has been considered. However, during project implementation feasibility will be examined for drawing power from the grid.

vi) For the purpose of calculating manpower requirement, operating staff strength at similar terminals has been considered as a basis.

CHAPTER 4
Basic Engineering

4.1.0 Pipeline Construction Onshore

4.1.1 Engineering For Construction

Pipeline construction usually takes place in relatively isolated areas. Transportation, usually by bus, is provided to the worksite.

Typical pipeline construction activities include, in sequence

- Route surveying.
- Mobilizing equipment and personnel.
- Preparing the right-of-way (clearing and grubbing the right of way.)
- Transporting and storing pipe and materials
- Topsoil stripping
- Grading
- Stringing (transport and laying of pipe on the ROW)
- Transporting other materials and weld equipment to the site.
- Welding, ultrasonic, and X-ray checking of welds
- Installing protective coating at pipe joints
- Jeeping pipe (testing for external coating integrity)
- Trenching
- Lowering pipe into the trench
- Installing watercourse crossings
- Installing block valves and terminous equipment
- Backfilling
- Leak testing (hydro testing)
- Restoring the ROW
- Inspecting the route
- Demobilizing equipment and personnel
- Installing cathodic protection

4.1.2 Construction Surveying

A construction survey is performed to gather detail data to complete the design of all sections of the pipeline, including associated access roads and watercourse crossings. Woodcutting in the surveying area will often leave merchantable timber in salvageable lengths of 4 feet or greater. Care has to be taken to ensure that no cut brush and trees are left in watercourses where they may form artificial barriers for water or fish.

Pipeline construction workspace requirements are a function of pipe diameter, equipment size, slope conditions, bedrock, the location of construction, pipeline crossovers, the method of construction and the existing soil conditions during construction. Larger equipment is needed to handle the heavier pipe, thereby increasing the amount of construction workspace required.

Typical construction ROW widths using various pipe diameters are presented in **Table 8**

Pipe Size (mm)	Working side (m)	Spoil side (m)	ROW width (m)
60.3-114.3	9	7	16
168.3-273.1	10	8	18
323.9-457	14	9	23
508-660	15	10	25
762-914	15	11	26
1067	17	12	29
1219	18	13	31

4.1.3 Clearing

The area of the right-of-way, all temporary working space, and access routes used for construction are completely cleared of trees and brush. Bulldozers with special

attachment cut or knock down any remaining material. The material is then piled and burnt.

As clearing progresses gates are installed on all fences. Underground utilities or structures are hand exposed and protected with ramps or others means to prevent damages by equipment and vehicles.

A typical clearing crew and equipment would include a foreman, several operators, labourers, a complete dozer with cutting blade /angle blade and winch. The clearing crew will do the minimum grading necessary to accommodate vehicles used to transport personnel, fuel and equipment to the site.

4.1.4 Grading

Topsoil and organic surface material is stripped and stored away from ditch line areas, ditch spoil areas and all areas to be graded. This grading consist of the following areas:

- Top soil storage area
- Ditch spoil area
- Ditch area
- Pipe area
- Pipe laying equipment areas
- Vehicles and equipment passing

The passing lane must be eliminated on slopes that require heavy grading or are very rocky. On side slope site working may be constructed by fill. The ditch may be excavated in previously undisturbed soil so that the pipe is left on undisturbed soil. Grading is done so that conventional vehicles can travel along most of the right-of way. In steep, rugged terrain where this grading is not practical, it can be limited to the amount necessary to install the pipe, using towing equipment or winches.

Drilling and blasting with explosives will be required where the rock is too hard to break by ripping. Explosive charges are placed in the holes made in the rock and then detonated. This procedure needs to be approved by the appropriate regulating authorities.

4.1.5 Loading, Hauling and Stringing

Pipes are received from stockpiles, which is away from ROW. Crane is used to load the pipe on trucks. The trucks then haul the pipe to the row where it is offloaded with a side boom and placed on wooden skids, end to end on the ROW. The pipes are angled slightly to allow end hooks to be removed and to prevent damage to bevels.

Special precautions are required to prevent damage to the pipe or coating. These precautions include using rubbers or others suitable material between the pipe and the tie down chains, using padded bunks and covering the pipe with load with tarpaulins.

4.1.6 Bending

The pipe will require bending to accommodate changes in direction and elevation of the trench. Bending is done or after trenching is complete. Large diameter pipe must be precisely bent to avoid costs and delay due to cutting and rebending or redigging the trench during lowering-in. large diameter pipe is bent using a hydraulic bending machine and an internal mandrel. Areas contacting the pipe will be padded with neoprene rubber when precoated pipe is used. The bending is accomplished by cold stretching the pipe material. The bending engineer will allow for lapping where tie-ins are required (e.g., road crossings, side bends, test points). Generally we use three types of bends

- 40 D bend for diameter 18" and above

- 30 D bend for diameter up to 16". These are cold field bends.
- 6 D bend when 30 D and 40 D bends still crosses the ROW limit. It is a machine bend

4.1.7 Trenching

Normally trenching is done using wheel ditchers, supplemented by back holes to dig side bends and areas requiring extra depth. Wet areas and rock trenches are dug entirely by back holes or equivalent machinery.

Where the pipe has been bent ahead of trenching extra care including the use of cut stakes may be necessary to ensure that the pipe fits the ditch. Attention is required at crossing and other tie in locations to dig the extra width and bell holes to allow welding to be done in the trench.

4.1.8 Coating

All weld areas require cleaning and coating after NDT testing has been completed. Precoated pipe will be electrically checked for damage. A typical equipment would include a sandblast unit complete with an air compressor, an induction coil complete with generator, an epoxy powder application unit.

4.1.9 Lowering In

The pipe is lowered into the trench using several side tractors working together. The pipe coating will be inspected again using a "holiday" detector and repairs will be made as necessary. Cradles (which roll along as the pipe is lifted) or wide nonabrasive belts are used for lowering the pipe depending on the length of section and the terrain.

4.1.10 Crossings

A separate crew, working ahead of the tie-in crew can bore through roads, railways and highways to avoid interruption in service and damage to the surface. The number of crossings, the terrain and the water table conditions are the major considerations when deciding whether to use a separate crew. The necessary equipment would include side booms, boring machine, backhoes, and ditch pump.

4.1.11 Fabrication

Fabrication is the term used to decide assembly consisting of pipe valves, fittings and instruments required to commission and operate the pipeline. It normally includes the welding required to complete the assemblies to the extent that the pieces may be hauled to the final location. The assembly will be completed and installed by a tie-in crew. Completed assembly requires the hydraulic pre-test prior to welding to the pipeline and backfilling. Foundations are required to support the weight of these assemblies and to absorb the thrust from subsequent gas blow downs. The type of foundation will depend upon ground conditions and may consist of concrete blocks, concrete piles or steel piles.

4.13 Cleanup

Clean up involves restoration of the ROW, temporary workspace and temporary access routes to their final state for operation of the pipeline. Specific activities include removal of gates, rocks, debris and excess spoil, removal of temporary bridges, installations of erosion control measures and replacement of topsoil. Cleanup is done prior to hydrostatic testing to the maximum extent possible.

4.1.14 Major water crossing

Major water crossings, either large rivers or long swamps, must be constructed using special procedures and equipment. Pipelines across rivers are usually installed by pulling the pipe under the river with a cable using a stationary or tractor-mounted winch. As many side booms as necessary will carry the concrete-coated pipe to the edge of the water on the side where the pipe section has been welded and concrete-coated. Intermediate welds in the section will be required, depending on workspace and equipment availability. The trench will be excavated using a large dragline, a backhoe, or a clam working on a sled or a barge. The depth and flow of water and the riverbed material will determine the method to be used to excavate and backfill the trench.

Long swampy areas will be crossed by pushing the concrete-coated pipe along the water-filled trench, buoyed with empty barrels or similar flotation that can be released after the pipe is in place. The individual joints of pipe are concrete-coated and welded together, and moved into position using a push station. The trench will be excavated and backfilled using a backhoe, dragline, or clamshells working from swamp mats. In situations where the excavation depths, are greater than 30 *feet* below the mean water level, clamshells mounted on barges are used to excavate and then backfill the installed pipe.

4.1.14.1 Trench less Crossings

Notwithstanding the widespread historical use of trenching as a means of crossing rivers, one of the most significant challenges facing the pipeline industry is compliance with increasingly stringent environmental regulations. Regulatory expectations, particularly in North America, are becoming increasingly neutral to the cost of crossing installations and are demanding a more thorough assessment of a wider variety of river crossing options, including trenchless technologies.

Perhaps the most commonly used is the directional drilling process, which has been accepted by most pipeline companies as proven technology.

Directional drilling has the following **advantages** over open trench excavation

- The riverbanks and the sensitive ecosystem along riverbanks are not damaged. Since there is no excavation in the river itself or along its banks, there is no silt buildup or bank erosion. It is not necessary to take special measures to protect the marine life.
- The workspace is much smaller. One only needs to accommodate the fixed machinery at both ends, plus a *few* backhoes and a crane and the water-based mud pits. Most importantly, the amount of material removed from the hole is many times less than would be excavated using normal open-cut techniques.
- The river can be crossed at almost anytime, (i.e., during fish spawning or high flows).

Directional drilling however has it **limitations**

- If the soils are inconsistent, filled with till (small loose-packed stones); sandy, or too water-laden, the directional drilling has a lower chance of being successful and is sometimes impossible.
- It is a high-cost operation, usually charged by the day, and if unsuccessful the crossing must then be open-cut, increasing the cost even more.
- It requires a high-cost; wear-resistant pipe coating for the pull through. One cannot be sure there has not been some coating damage.

4.1.14.2 Horizontal Drilling

There are two stages to direction drilling; the first involves drilling a small diameter pilot hole along a designated path, while the second one involves enlarging the hole to accommodate the pipeline. A steering bias is created by the

asymmetry of the leading edge. If a change in direction is required; the drill string is rolled so that the direction of bias is the same as the desired change in direction. Drilling progress is normally achieved by hydraulic cutting action with a jet nozzle. Mechanical cutting action, when required, is provided by a down hole positive displacement mud motor.

The actual path of the pilot hole is monitored during drilling by taking periodic readings of the inclination and azimuth of the leading edge. These readings, along with measurements of the distance drilled since the last survey, are, used to calculate the horizontal and vertical coordinates along the pilot hole, relative to the initial entry point on the surface.

The pilot hole is enlarged using a reaming process, which can either form part of the pullback process or be completed prior to it. Ordinarily the reaming tool is attached to the drill pipe at the exit point. The drill pipe is then drawn toward the drilling rig as the reamers rotate, thus enlarging the pilot hole. Sections of drill pipe are continuously added as progress is made, to ensure that there is always a string of pipe in the hole. The reaming tools consist of a circular set of cutters and drilling fluid jets. The pressurized drilling fluid serves three purposes: to cool the cutting tools, support the reamed hole, and lubricate the trailing drill pipe. In soft soils with small-diameter lines, pre-reaming is unnecessary and the final installation phase is undertaken when the pilot hole has been completed. In this circumstance the reaming assembly is attached to the actual pipeline pull section and sections of pipe are added as the reamer progresses towards the drilling rig. In order to minimize the torsion acting on the pipeline a swivel is used to attach the pull section to the leading reamer.

4.1.15 Welding

Welding is required for double jointing, preparing sections for crossings, mainline welding, tie-ins, and fabrication. Welding processes that are commonly used for

pipeline applications are gas submerged arc welding (restricted to double-jointing and fabrication), shielded metal arc welding (SMAW), or gas metal arc welding (GMAW). Either a mechanized welding technique or manual welding may be used for mainline welding; manual welding is used for any other requirements.

Gas metal arc welding (GMAW) is done using a consumable wire that melts when an arc is struck and maintained between the wire and the material being welded. The welding wire is fed continuously into the arc during the welding process.

The flux coating is required to shield the arc and molten metal from the atmosphere, add alloying elements to the weld metal, and provide a protective layer (slag) during and after solidification of the weld metal. This slag is subsequently removed between passes.

Shielded metal arc welding remains the most widely used and versatile process for general pipeline applications. With the correct choice of consumable and welding technique the SMAW process can be applied to all welding positions and will allow a wide range of mechanical property requirements to be met. However, the process is very dependent on the welders' manual skills for attainment of defect-free welds with acceptable properties. Production is inherently limited by its intermittent nature, and a duty cycle of 40% is typical. Most of the developments in arc welding have been aimed at overcoming both these limitations.

Multiple welding passes are required to complete each weld. The number of passes is dependent upon the pipe wall thickness and the welding process used. The first pass is called the stringer bead, which is followed by the second, called the hot pass. All open ends of welded sections are securely night-capped at the end of each day, no waste material or debris, such as welding rod stubs is left on the right-of-way or placed in the pipeline trench. All welds found to be unacceptable by nondestructive testing are cut out and replaced or repaired using a qualified procedure; gaps that are left in right-of-way are necessary for landowners, live stocks / wildlife.

4.1.16 Valves

In the pipe section valves need to be installed to isolate the section of the pipeline so that the section of the pipeline can be divided into various section and can be isolated in case of any emergency such as bursting or leakages etc.

4.1.17 Required spacing of valves

(a) When determining the sectionalizing valve spacing, primary consideration will be given to locations that provide continuous accessibility to the valves.

(b) The spacing between valves on a new transmission line should not exceed:

(1) 20 miles in areas of predominantly location class 1

(2) 15 miles in areas of predominantly location class 2

(3) 10 miles in areas of predominantly location class 3

(4) 5 miles in areas of predominantly location class 4

Valves on distribution mains, shall be spaced as follows:

(a) High pressure distribution systems:

Valves installed in accessible location to reduce the time to shut down a section during emergency and due consideration given to size of mains, operating pressure, local physical conditions as well as number and type of consumers affected by the shutdown

(b) Low pressure distribution system:

Valves may be used on low-pressure distribution system.

4.1.18 Location of valves (Transmission valves)

(a) Sectionalizing block valves: shall be accessible and protected from damage and tempering.

(b) Sectionalizing valves: installed above ground, in a vault or buried.

(c) Blow down valves: provided such that each section of the pipeline between main line valves can be blown down.

Valve son distribution mains, shall be located in a way to provide ready access and facilitate their operation during an emergency.

4.1.19 Sectionalising Valves

Sectionalizing valves would be provided in accordance with the requirements of the code in order to isolate various sections of pipeline. These valves would be full-bore ball valves with stem extension and manufactured in accordance with API 6D.These valves would also be provided across major rivers.

4.1.20 Flow Tees

All branch connections on the main line, which are greater than 40% of mainline, would be provided with c flow tees to allow smooth passage of pigs. Flow tees materials would be same as that of line pipe.

4.1.21 Insulating Joint

Insulating Joints would be provided at transition point of above ground and underground portion of pipeline for Electrical isolation. These would be Mono-block type suitable for both above/below ground installation.

4.1.22 Scraper Traps:

Scraper traps would be provided at all intermediate booster pump stations for launching & receiving pigs. The trap will be barrel type and will have hinged quick opening and closure for quick opening & closure of the barrel.

4.1.22 Corrosion Coating:

The pipeline will be protected against external corrosion by a combination of PE coating and impressed current cathodic-protection system.

4.1.23 Pipeline Crossings:

The Pipeline on its way from Rajmandary and Hyderabad to Mumbai crosses numerous crossings viz Railways, Road, Rivers, Streams, Nala etc. The pipeline will be buried with minimum cover of 1.0 meter. The depth of cover at crossings will be more than 1.0 metre.The No. of crossings for each section of the pipeline is given in the following Table:

Table 8: Pipeline Crossings

SR.NO	TYPE OF CROSSINGS	Rajmundry TO Amravati	Amravati TO Hyderabad	Hyderabad To Pandarpur	Pandarpur TO Mumbai
1.	RAILWAY	5	7	3	5
2.	ROAD	12	1	21	19
3.	RIVERS	4	1	0	3

Pipeline will be designed and constructed in accordance with ANSI B31.4 - Code for Pipeline Transportation system for Liquid hydrocarbons and other liquids and OISD-141

CHAPTER-5
Project Execution

5.1 stages

Different stages of the project Execution are indicated below:

i) **Pre-Project Activities.**
ii) **Detailed Engineering.**
iii) **Procurement.**
IV) **Tendering & Construction.**
v) **Commissioning.**

There will be considerable overlap of these stages over one another. Activities under the various stages of the project are described in the following paragraphs.

5.1.2 Pre-Project Activities

These are the activities to be taken up before the "Zero Date" of the project. A 36-month schedule for this size of at pipeline project which comprises of a number of pipeline sections of different sizes including spur pipelines, totaling over () KM length of pipelines with cathodic protection, telecommunication and SCADA facilities, a number of intermediate compressor stations .

It is recommended that the pre-Project activities are continued by RIL till government approval for implementing the project is received.

It is relevant to state that this DR (Design Report) has been prepared based on the preliminary basic designs on the basis of desk-top study of the relevant SO! Topo maps. The pipeline route and the basic designs can be finalized only after receipt of the final reports of the detailed surveys, environmental impact study, etc.

5.1.3 Detailed Engineering

The detailed engineering will comprise mainly of the following:

5.1.3.1 Detailed Engineering for Procurement

Based on the basic process designs and the survey reports, design industry will prepare detailed technical specifications\in the form of material requisitions (MR) for procurement of all equipment and materials.

As part of the detailed engineering services, Design Company will also carry out techno-commercial evaluation of the vendor offers received and prepare recommendations for RIL approval. Review of vendor's critical drawings will also be carried out by Design Company.

5.1.3.2 Detailed Engineering for Construction

The detailed engineering for construction will be divided into two Stages, viz. tendering stage and construction stage. During the tendering stage, Design Company will prepare the technical specifications for various work tenders, carry out techno-commercial evaluation of the bids received and prepare recommendations for RIL approval. The second stage will cover preparation of major engineering drawings for construction. These drawings will be based on the basic engineering, the survey reports and the vendor data available. Design Company will also carry out review of contractors critical detail drawings wherever essential.

5.1.4 Procurement

As part of procurement activities, Design Company will prepare vendor list for procurement of equipment and materials, obtain quotations, carryout techno-

commercial evaluation of the quotations received and prepare recommendations for RIL approval. After receipt of RIL approval, prices will be evaluated and final recommendation will be prepared for RIL concurrence. Purchase orders and LC (wherever required) will be issued by RIL. Subsequent follow-up with vendors for expediting vendor drawings, manufacturing and delivery, shop inspection and coordination for inland transportation will be entrusted to Design Company. The responsibility will extend till equipment and materials are delivered in safe and sound condition at site.

5.1.5 Tendering, Construction and Commissioning

Following construction tenders have been envisaged for execution of the project:

a) Pipeline **Work**

i) Coating & wrapping of line pipes

ii) Pipeline laying including temporary and permanent Cathodic protection, installation of SV, CP and repeater stations and laying of optical fiber cable.

iii} Construction of river crossing by Horizontal Directional Drilling, if applicable.

iv} Telecommunication and SCADA.

B) For Terminal/Station **Work** (for each station/terminal) Composite works tender for each terminal/station comprising of the following works:

- Site grading
- Construction of boundary walls
- Civil/structural works including buildings,
- Roads, culverts, drains and waste disposal;

- Mechanical works including plant piping,
- Equipment erection
- Construction of switch yard;
- Electrical and instrumentation works;
- Fire protection and fire fighting facilities,etc.

The pipeline contract is proposed to be executed on multi-spread basis. The contract will be awarded either to a single contractor capable of mobilizing adequate manpower and machinery for an average combined monthly production of about 100 Kms of pipeline laying in all spreads or to different contractors on spread basis to achieve the targeted progress.

Contracts for composite works for terminal/stations will be assigned to one or more agencies depending on contractor's capability/capacity.

For both pipeline and terminal/station works, procurement of all materials other than free issue materials will be included in the scope of the contractor(s).

Contracts for Telecom & SCADA will be awarded on package basis which will include design, procurement, installation and commissioning of the systems.

Be prepared by EIL who will also invite bids, and, after detailed evaluation of the bids received, will prepare techno-commercial recommendation for RIL approval and for placement of work order by RIL. Design Company will also review the design carried out by the LSTK contractors.

The duration for execution of various construction works mentioned above have been indicated in the attached Project Schedule.

Design Company will provide necessary construction management and supervision services during the construction stage and will assist the owner in commissioning the system.

5.2 Project Management

The responsibility of project management for overall Coordination and supervision of all activities described above is proposed to be entrusted to Design Company. For monitoring progress of the project, a detailed project schedule with bar-chart/network will be prepared and issued by Design Company and monthly progress reports detailed the achievements, hold-ups, etc., covering all the activities from basic engineering to commissioning will be issued to exercise proper control during execution of the project.

Various procedures for performing all the above activities wi11 be prepared by Design Company and approved by RIL.

It is proposed that RIL will entrust Design Company to Provide the Consultant's services for design, Engineering, procurement, tendering, construction supervision, start-up & commissioning and project management services for implementation of the project .These services will be provided by Design Company in accordance with the applicable Indian/international codes, standards, regulations, and, sound and established practices.

5.3 Assumptions/Constraints in Project Execution

As per the experience in executing similar major projects, it will be relevant to mention that this project will not be totally free from constraints, and, a few of the constraints envisaged and assumptions governing the project execution are discussed below:

i) Intensity of rainfall and duration of monsoon will affect the field activities, particularly in the cultivated land, low lying areas, etc. Construction activities will need to be planned ,properly to minimize the effect of monsoon on the progress of the work.

ii) NOC/permissions will have to be obtained on priority basis for laying the pipeline in forest/ plantation areas and in the vicinity of other existing pipeline and across major roads and railway lines.

iii) The work at the major river crossings will have to be carried out at low tide and during lean/dry season. The schedule for the project will depend upon the type of crossings adopted for the river crossings. The overall schedule may be affected if bridge crossing is adopted. Survey work will need to be completed before the Zero Date for freezing basic engineering parameters.

v) Acquisition of ROU for pipeline laying and land for pumping facilities at the despatch terminals, intermediate booster, SV and pigging stations,etc., will need to be completed on priority basis.

vi) Critical items, viz., line pipes, valves and compressors will need to be procured on priority basis.

vii) Controlled blasting will be required for excavation work in rocky terrain. However, manual excavation may also be done in such terrain for pipe laying. Excavation in marshy and populated areas and in ghat section is envisaged to be done manually.

viii) Pipe laying in the forest section and the ghat areas will need to be done with proper care and planning and close monitoring will need to be maintained.

ix) Competent contractors for Telecommunication and SCADA works will need to be selected, who could complete the works as per the project schedule.

CHAPTER-6
Processes Description

6.1 General

This chapter covers the basic process designs carried out for the project based on the design basis and the system techno-economic study included in the preceding chapters of this Report.

The basic process designs are given for the dispatch terminals, the pipeline system. Basic Process Design for the Pipeline System Product Characteristics

The NG characteristics given as under have been considered for design of the despatch terminal of pipeline and metering facilities.

Product	: NG
Product Specification	: major portion is methane with some minor portion of $C_2, C_3, C_4, C_5, N_2, CO_2$

The battery limit design conditions for the tap-off terminals shall be as follows designed as per demand of gas (ie the gas which is left after utilization in power station at Mumbai)

6.1.2 Utilities

The following utilities will be required for the operation of the despatch terminals and tap-off stations:

- Power, Emergency power, UPS
- Plant/instrument air

- Water including fire water and drinking water

Provision has to be kept for supply of utilities at the battery limit from the facilities at the terminal locations. For the remote areas, diesel driven power generation facilities will be provided.

Despatch terminal/Receiving terminal/pig (launching /receiving) terminal

6.2 System Requirements

Facilities to be provided for a pipeline system should be assessed based on its requirements. Following basic information should be assessed to plan for the facilities to be provided.

- Product(s) to be transported points
- Origin and destination points
- Throughputs and operating schedules
- Proposed schemes for pipeline transportation
- Route options and approximate lengths
- Possible alternative modes of transportation
- Amenability to transportation by various modes
- Preprocessing/conditioning required for transportation
- Available upstream and down stream facilities
- Process units
- Storage
- Existing handling and transportation facilities
- Sites for terminal facilities
- Route corridor
- Communication
- Utilities
- Infrastructure

Various options and configurations should be conceptually formulated and their feasibility established. Also techno-economic comparison should be carried out with other modes of transportation prior to final selection of mode of

transportation. Studies should be carried out for optimization and selection of the following major components.

- Route and network
- Pipe size, grade and wall thickness
- Product conditioning and flow improvement
- Internal corrosion control
- Number of pumping stations
- Batching and tank age optimization for multi-product pipelines
- Type of pumps and drives
- External corrosion protection
- Power supply
- Telecommunication and SCADA
- Special construction requirements

6.3 Facilities

Based on assessments above facilities for a cross-country oil pipeline system may be provided as follows

6.3.1 Despatch Station

Despatch station would generally include receipt at the battery limit of the product to be transported and necessary filtration equipment, metering and other instrumentation to monitor and record the product quantity, quality and battery limit parameters. Additives for flow improvement and/or corrosion inhibition may be injected if required based on process design prior to commencement of pumping of the product through the pipeline.

Mainline pumping units generally provided are, of centrifugal type connected either in series or parallel or both as per assessment of variation in flow and pressure requirements. Standby pumps are provided looking into requirements for

maintenance and desired availability of equipment for operation. Positive displacements pumps are generally recommended for transportation of highly viscous fluids. Over-pressure protection and pulsation dampening devices are generally necessary with these pumps.

The pump drive in most cases is an AC motor. However, in the event electric power is not available or is unreliable, crude oil or diesel engine driven pumps may be used. In case desired with AC motors, speed control devices such as frequency controllers, eddy current couplings, fluid couplings, etc may be used for control of flow parameters.

Instrumentation should be provided to monitor, and control the system parameters and operation of various equipment provided. Safety devices, alarms, interlocks and shutdowns are provided for safety of the system. A control room is provided at the despatch station to monitor and control the parameters and operations. The control room is linked to other facilities along the mainline through the telecommunication link and/or Supervisory Control and Data Acquisition systems as provided.

A scraper launcher should be provided for launching of pigs proposed to be launched through the pipeline. A pig signaler is provided to monitor the passage of the pigs launched.

Insulating joints are provided at transition with buried cathodically protected section of the main pipeline.

Station isolation valve is provided to isolate the terminal facilities from the pipeline to limit damage case of a mishap.

Fire fighting facilities, utilities and other facilities as necessary should be provided.

6.3.2 Intermediate Pump/Compressor Stations

Intermediate pump/compressor stations may need to be provided depending on the pipeline length, estimated pressure losses and optimization of pipe and pump parameters. Facilities at the intermediate pump/compressor stations are provided on similar lines as per the main pump station or compressor station at the despatch station.

6.3.3 Other Intermediate Facilities

Pipeline route is investigated based on study of various route options on maps followed by ground reconnaissance and optimization studies. Detailed survey is carried out on route option finally selected.

Salient aspects to be considered in route selection are.

- Route length
- Ground feature, terrain and soil
- Habitation and growth potential
- Crossings and obstructions
- Restricted and environmentally sensitive areas
- Construction requirements
- ROU acquisition and statutory clearances

Pipeline size is chosen based on optimization studies and process design. Materials and grades compatible with the product transported are considered. Various combinations of material grades and wall thick nesses are considered meeting the design and construction requirements. Selection is finally made looking into availability and costs.

Cross-country pipelines are generally laid buried because of the following reasons

- They are less susceptible to willful or accidental damage
- Permanent right of way is not required
- Under ground pipelines are subjected to lower temperature variations
- Damage/deterioration is less due to climatic and/or human factors
- Interference in populated areas is avoided
- Natural environment is preserve
- Land is restored for original use

External corrosion protection has to be provided for the buried and the above ground pipe sections. Above ground pipe sections are protected using paints suitable for the environment. For the buried pipelines suitable external coatings should be selected for protection against corrosion from galvanic stray-currents and bacterial effects.

External coatings generally considered are

- Coal tar enamel with fiberglass reinforcement
- Polyethylene
- Epoxies

Depending on selected coating and application method the coating may be applied in yard in controlled conditions or over the ditch in the field. Coating application in yard is preferred for better quality control. Field weld joints are coated during construction. Cathodic protection (CP) is provided to buried pipelines in addition to external coatings for protection against corrosion. Cathodic current is superimposed on the pipelines to guard against corrosion due to break in protective coatings over the lifetime. Usually CP stations with transformer rectifier units connected to an AC power source and anode beds are provided uniformly spaced along the length of the pipeline. If power supply is not available

or is not reliable, other or back up power sources (solar panels, generators, battery back ups etc.) would need to be provided. In some cases protection may be provided using DC batteries or sacrificial anodes. Soil resistivity survey should be carried out prior to design of CP system.

6.3.4 Facilities For "Pig" Or "Scraper" Launching And Receiving

These are provided to facilitate the following operations

- Cleaning or "scraping" of pipelines of dirt corrosion products and residues.
- "Gauging" to detect deformations.
- "Caliper" pigs to detect and locate deformations.
- "Batching" for separation of two products and for line titling.
- "Intelligent pigs" to detect and locate defects and metal loss.

For pigging, a scraper launcher is provided at the Despatch Station and a receiver at the Receiving Station. Pigs are launched with the fluid flow. Intermediate stations are provided at suitable intervals depending on the product and the length of the pipeline.

Attempt is usually made to club the intermediate pigging stations with intermediate pump stations or other intermediate facilities.

Block and isolating valves (sectionalizing valves) are installed for limiting hazard and damage due to accidental discharge and also to facilitate maintenance. Valves are provided at accessible locations with protective enclosures. Main line block and isolation valves are provided at following locations. Both side of major river water crossing. A check valve may be used alternatively on down stream side. Pump station isolation. Industrial, commercial & residential areas. For HVP/LPG

lines maximum spacing to be 12 Km in these area. Check valves to prevent backflow depending on terrain and type of fluid handled. Remote operated valves for remote controlled facilities.

6.3.5 Receiving Station

Facilities at receiving station would generally include station isolation, scraper receiver and backpressure control and delivery facilities for custody transfer at battery limits. Necessary piping, filtration, metering, other instrumentation and controls are provided according to the requirements.

A control room should be provided to monitor and control the operations at the receiving terminal with the necessary link with despatch and other stations through the telecommunication link and/or the SCADA system provided. In some cases storage facilities for the transported product may also need to be provided prior to custody transfer.

6.3.6 Instrumentation and Controls

For the efficient and reliable operation of the pipeline system,

The following instruments/controls will be provided:

6.3.6.1 Despatch Terminal

All controls, recorders and remote indicating devices will be mounted on a control panel. All compressors will have status indication on the panel. All motor operated valves will also have position indicators and provision to operate the valves from the control room. In addition, the control panel will have station sequence, compressor unit sequence and alarm devices.

All sectionalising valves (SVs) will have position indicators at the terminal control panel. The SVs will also have provision to be closed simultaneously from the control room, opened individually from the control room.
The Domain units will have provision to stop manually.

In the event *of* the motor stopping, the valves on the suction and discharge *of* the pumps will close automatically. The main compressing units will shutdown automatically in the event *of* low suction pressure or high discharge pressure .Station operation is described as under(Sectionalising Valve Check and open all sectionalising valves *of* pipeline .compressor Each intermediate Compressor will be equipped with a Compressor unit sequence startup. The Compressor motor will be started.

6.3.6.2 Mainline Compressor

The Compressor unit sequence will start the Compressor in the manner described as above (under INTERMEDIATE Compressors) the station sequence will send a signal to the Compressor unit sequence of the second Compressor. The standby Compressor will be kept off-line the operator. The Compressor unit sequence wi11 start the second Compressor in a similar manner as described above. The station sequence will also send a signal through RTU to all the intermediate Compressor stations.

b) Intermediate Compressor Stations

As soon as the signal from the previous station is received, the operators at these stations will monitor the arrival of the NG and select the Compressor unit sequence for startup.
The operations will be exactly similar to the one described above (except where there is only one pump to be started, the step to start the second compressor described above will be skipped.)

The compressor unit sequence will check the position of MOVs (ROVs) on suction and discharge lines of .the compressor and bring them to open or close positions required for the particular operation.

The products will be metered by single run turbine meters with 1O% standby at the despatch terminal and the receiving terminals. Critical parameters at the tap-off station_ such as, pressure, flow density, etc. will be telemetered to the dispatch terminal.

All SVs could be closed from the control rooms through remote terminal unit (RTU)in case of emergency.

6.4 Utilities

The facilities for supply of following utilities will be. Provided in all the despatch/booster station terminals as per the design:
Compressed air {plant air and instrument air}

- Service water system
- Cooling water system
- Power Emergency/UPS

6.5 Instrumentation/SCADA, Telecommunication and CP Systems

6.5.1 Instrumentation Control & SCADA System

i} Instrumentation & control System

1. Instrumentation and control system will be provided for safe and efficient control of NG Pipeline.
2. Instruments for measurement and control will be provided for safe and efficient control of NG Pipeline.
3. Instruments for measurement and control will be either locally operating in the field or in control room based on combination of both local and remote operation.
4. Safety system wi1l be designed to protect men, machinery and environment. It wil1 include early warning alarm systems and where feasible, systems for shutdown.
5. Engineering, design and installation of instrumentation and control system will conform to International standards and Indian standards, along with practices of sound and safe engineering. Instruments and systems will be of proven quality and will be tested and calibrated for safe and easy operation.
6. The various instruments including indicators, controllers , recorders, flow computers, multipoint digital temperature indicators, alarm annunciators, push buttons, lamps, etc. will be located on control panels.

7. The density measurement and interface detection will be carried out at Dispatch terminals and tap-off stations. Turbine meters will be used for measuring volumetric flow
   rate at the following locations:
   Rajamandary,Amravati,Hyderabad,Pandarpur & Mumbai The control valves actuators will be electro-hydraulic type wherever instrument air is not available.

6.5.2 SCADA System

"The aim of SCADA system is to ensure effective and reliable control, management and supervision of the pipeline from a centralised location using remote terminal units (RTUs) located along the pipeline at suitable locations.

6.5.2.1 Scope of SCADA System

The pipeline is envisaged to be monitored and controlled from Central SCADA Control Centre (SCC) located at Central Station at Mumbai.
The scc will be interlocked through fibre optic link with Remote Terminal Units (RTUs) located along the pipeline. The following pipeline facilities will be considered for telemetry operation:

a) All Despatch Terminals
b) Sectionalising Valve Stations

RTUs are envisaged in the SCADA system covering the requirements of points a, b & c above. RTUs will be used for scanning and telemetering of pipeline parameters such as flow, temperature, pressure, valve status, scraper status signals, density, CP parameters etc. to update the host computer database at Mumbai see for monitoring the entire pipeline operation. The SCADA system will also be used for remote closing of sectionalizing valves.

The system hardware will be based on dual 32 bit computers with associated terminals, printers, peripheral attachments, local area network and communication controllers.

The application software will consist of leak detection software and batch tracking software.

6.5.2.2 Leak Detection Study

A suitable real time leak detection system will be provided. The system will be integrated with SCADA network.

a) Leak Detection Methodologies

Leak detection for GAS grade hydrocarbon pipelines can be carried out primarily by one or combination of following three methods:

1. Volume Balance
2. Transient modeling
3. Negative pressure wave detection

The selection of the suitable method or methods depends on the environmental and safety considerations and operation philosophy of pipeline in general. Given the hardware and software platform for the SCADA system, the implementation task for these methods becomes much easier.

An attempt has been made in the following Sections to highlight the functioning of these methods along with their features and limitations and in the concluding section, suggestions have been made for selection of these methods.

6.5.2.2.1 Volume Balance

Brief Description

The basis of the volume balance method of leak detection is a balance of fluid volume over each section of pipe. The volume balance relates directly to the

conservation of mass within the pipeline. A leak is present in the pipe section if the difference between the instantaneous inlet and outlet flows is different from the steady state inventory of fluid in the section.

Mathematically:

V(leak) =V(inlet) – V(outlet)- V(inventory)

In this method, the SCADA computer Calculates at time average value of the net inflow V(inlet) - V(outlet) – V(inventory) for each pipe section. If the average net inflow exceeds a threshold value (which takes into account instrument accuracy), a leak is reported.

Two types of volume balance: long term and short-term volume balance are calculated, using two different averaging times. The long-term balance gives high sensitivity to small leaks. The short-term balance provides fast response for large leaks.

Features:

This method is retrospective method in the sense that calculation of flow imbalance is continuously being carried out and leak above the detectable limit will not be missed.

Limitations

This method does not locate the leak and gives information about the leak only in between the flow comparison section.

This method does not take into account the dynamic inventory variations in the line.

Note :

By selecting the transient modelling, the dynamic inventory calculations are automatically available which would make this method fairly accurate. This method is highly dependent on instrument accuracies and drifts.
Note

Instrument analysis package is available as a part of transient modelling package, which would filter out unwanted effects and make the volume balance robust. The leak detection time is long.

6.5.2.2.2 Transient Modeling

Brief Description

In this method, a mathematical model of the pipeline is used to calculate and predict flow rates and pressures, which can be compared with measured values.

The boundary values for the model are taken from the measurements on the real pipeline by the SCADA system. The usual inlet boundary values are pressure, temperature and fluid composition and outlet boundary value is flow. The model then computes flow rate and Outlet pressure, temperature and composition. These calculated parameter are compared with measured values, when the deviation between calculated and measured values becomes greater than a certain threshold values, leak is reported.

Features

1. Retrospective
2. Detect and locate leak size under transient Conditions

3. Gradually occurring leaks can be detected.
4. Instrument analysis package, dynamic line pack calculations are automatically provided.
5. Batch tracking and batch interface contamination calculations are provided.

Limitations

1. Takes longer time to detect leaks with response dependent on leak size.
2. Leak location accuracy is limited.
3. Dependent on communication reliability

   A loss of communication can result in outage periods of one hour or more to restart and stabilise the model.
4. Instruments required should have good accuracy and very high repeatability.
5. The pipeline configuration changes result in lot of software efforts and changes at time become difficult.
6. The time and accuracy of leak detection/ location is deteriorated for compressible liquids.

6.5.2.2.3 Negative Pressure Wave Detection

Brief Description

When there a leak in the pipeline, the sudden pressure drops creates a rarefaction wave which propagates away from the leak site in both directions at the speed of sound. This wave can be detected by acoustic monitors placed at strategic points along the pipeline. The time taken to detect leak depends upon its distance from the nearest monitor and velocity of sound in the medium.

Features

1.Faster leak detection time for detectable leaks.

2.Detect leak location accurately.

3.Better method to detect sudden leaks.

4.Independent of pipeline instrumentation accuracy/drift effect.

Limitations

1. Transient phenomena
   - Not retrospective, Leak once missed cannot be detected again.(Retrospective, method must be used in conjunction, to prevent this happening.)
2. Does not keep track of batches in pipeline result in velocity errors effecting leak detection performance.
3. Cannot detect slowly occurring leaks.
4. Does not give much information about the Size of leak.
5. Performance deteriorates under transient conditions of the pipeline.
6. The spacing between acoustic monitors is required to be relatively smaller to achieve better sensitivity.

CONCLUSION

As can be gauged from the above, no one method covers the complete performance scenario expected out of the leak detection system. In order to achieve overall objectives of performing leak detection and location under various conditions of the pipeline, suitable combination of these methods need be selected.

It is imperative that volume balance in its simplest form does not satisfy the leak detection performance, and in order to minimize its limitations with respect to the requirements of dynamic inventory calculations, instrument analysis and composition tracking, part of processing of transient modelling need to be invoked. Looking at from another point of view, by employing transient modelling, volume balance computations are enveloped within the same.

The transient modelling enveloping volume balance and negative pressure wave

detection combination can functionally overcome limitations with respect to each method and provide a leak detection system with the following features as a whole:

- The methodology will be retrospective.
- It would provide high leak Detection accuracy,
  high leak location accuracy
- And minimum time for leak detection. It would provide fairly accurate leak detection size in addition to detecting gradually occurring leaks as well.
- The effect of leak performance due to pipeline noise, attenuation, compressible liquids and transient behaviour could be minimized.
- The effect of composition of liquid batches on the velocity of propagation of the sound wave could be taken care in the composite system.
- The hardware and software platforms of the SCADA system have been designed and sized to incorporate the composite methodologies.
- The details of the hardware and software's for SCADA system will be firmed up during detailed engineering at the stage of project implementation.

6.5.3 Telecommunication system

To facilitate proper operational and management control of Dedicated the pipeline, reliable and a telecommunication system is proposed to be set up connecting the various attended and unattended stations along the pipeline. The attended stations are at Dispatch Terminals.

The communication system proposed will provide for remote operation of sectionalizing valves along the pipeline along with communication amongst various attended stations. The system will also provide for voice communication from the unmanned stations to the attended stations and also remote monitoring of the cathodic protection and other operating data along with repeater stations equipment health data to the control station at Mumbai.

6.5.4 Cathodic protection System

For efficient and satisfactory functioning of the cross country pipeline system, both from the safety and economic points of view, the pipeline must be protected against corrosion which is a potential danger to the Pipeline

Both internal and external protection will be provided to the pipeline system. Internal protection is provided through injection of a corrosion inhibitor at the originating station with specified dosages in order to minimize internal corrosion.

i) External protection will be combination of corrosion coating and Cathodic Protection techniques. Conventional coating of pipelines by coal tar enamel reinforced with glass fiber with outer wrap has proved successful in the past. In the recent years, extruded or sintered polyethylene coating has been used increasingly. As opposed to "active" cathodic protection, coating is referred to as "passive" protection.

ii) Complete corrosion protection cannot be achieved practically by coating, as it

is impossible to fully avoid minor defects such as pores or cracks in the coating. Welded pipelines are particularly subject to corrosion at coating holidays because of their low longitudinal resistance, as they practically do not resist the flow of current through the pipeline. At these holidays, dangerous corrosion pitting is along the proposed line and the existing lines (protected and unprotected that may be found existing in and around the ROW).

iii) Temporary cathodic protection will be provided during construction phase of the proposed line by suitable means.

iv) It has been considered that there would be about a total of CP stations each at a span of approximately 30 KM and the selection of location of these Capitations and sizing will be done in such a manner that the entire line would be adequately protected. Wherever a telemetry repeater station happens to be located, location of a CP station will be made to coincide with it to avail of the common reliable power source and SCADA system.

V) All the cased road crossings will be provided with proper insulating separators, end seals and vent pipes. The casings will be well coated. Carrier portions inside the casings will be independently protected by sacrificial anodes.

vi) All major river crossings will be insulated by provision of insulating joints at both banks and extra care will be exercised for their protection by suitable means. Minor crossings need not be so isolated but extra care in their protection will be exercised.

vii) For monitoring purposes, test stations will be installed at approximately 1 KM interval. In addition, test points will be provided at all crossings and near Insulating Joints. Some test stations will have computerized facility for

automatic pipe to soil potential recording and later retrieval and transfer data to central monitoring station at Receiving Terminal through any RTU.

Viii) Interference effects wherever suspected or observed will be duly investigated and remedial measures provided wherever needed.

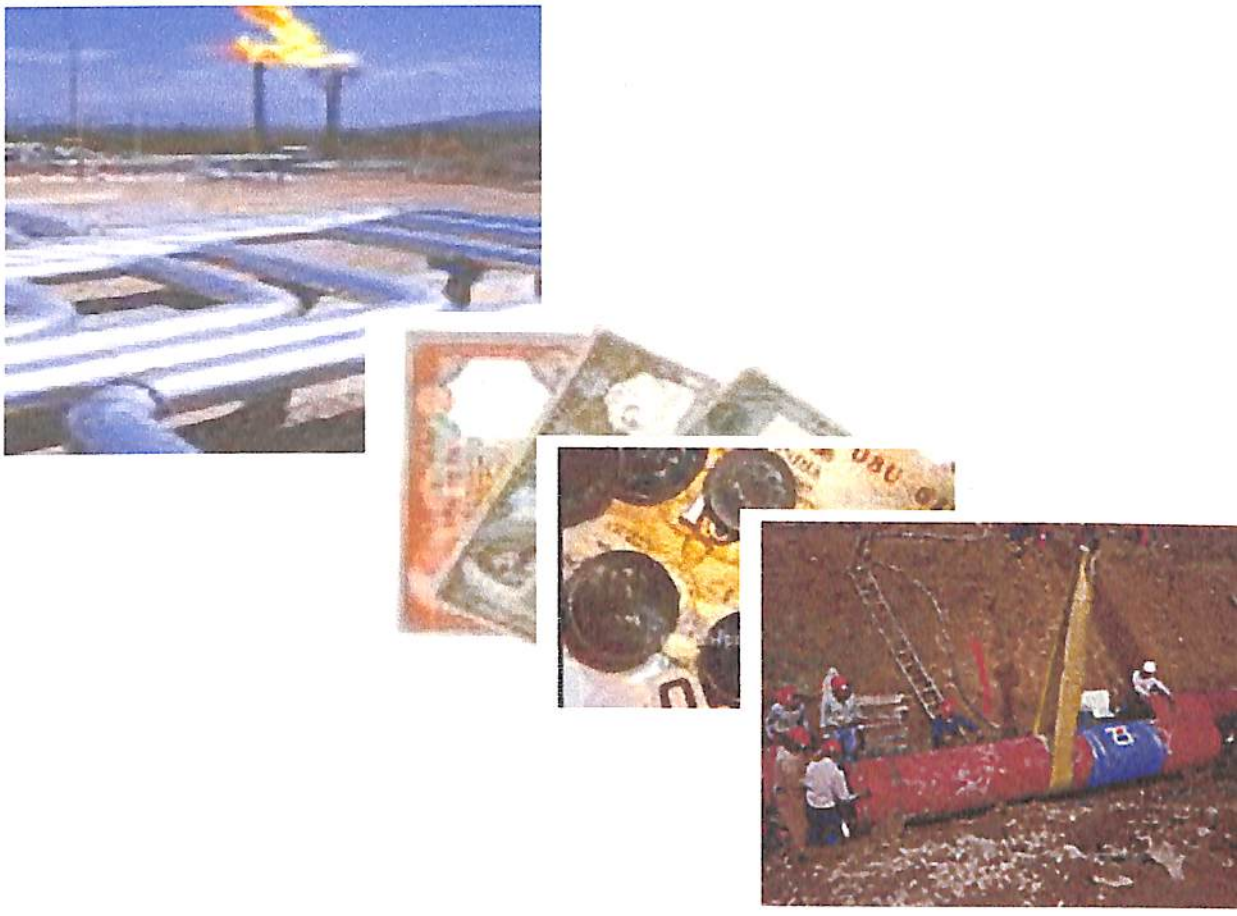
iX) Insulating joints will also be provided on the proposed line at all necessary located ions where electrical isolation is desirable such as at dispatch/receiving terminals. The grounding cells will also be installed at each location.

x) The design life of CP system is considered as 35 years.

xi) The central monitoring system will be adopted for the CP of the proposed line. Therefore, all CP stations will be provided with means for data acquisition which will be interfaced to the pipeline SCADA through a local RTU.

xii) Power supply at all CP, Repeater and SV Stations will be arranged through grid power/diesel generator system. For the eventuality of grid power failure, a suitable standby battery power system (low maintenance battery, indigenously available) will be provided with battery back up for 24 hours.

Possibilities of utilizing the grid power for these booster stations shall be checked and implemented during the execution stage. For remotely located booster stations, diesel driven pumps have been considered in DR.



CHAPTER 7
Cost Estimation

7.1 Capital Cost Estimate

A preliminary cost estimate has been prepared for the pipeline system for the selected option, viz., 44" line size, Rajmundry - Amravati - Hyderabad ,36" line size Hyderabad – Pandarpur - Mumbai Natural Gas pipeline.

The cost estimates have been prepared showing investment required. The capital cost of the project, is estimated as Rs. 3956.01 Crores including Rs. 58.67 Crores as FE in Phase I (Refer Capital Cost Estimate Table)

Tables containing detailed break-up of the capital cost for each dispatch terminal, Pipeline have been given in the accompanying Tables.

All the cost estimates are of cost level and do not include any future escalation

The basis of capital cost estimate is as follows:

7.1.1 Despatch Terminals, and Intermediate Stations

Cost of the pipeline facilities required at various terminals at Rajmundry, Amravati, Pandarpur, Hyderabad and Mumbai and at intermediate locations has been estimated based on the equipment list for each terminal, preliminary engineering and the available cost data adopted for time period and capacities.
Cost estimates for flow metering (Turbine flow meter of 44", Model TRZ-03 and flow computer Model ERZ-9004 of MIs RMG) is included.

A lumpsum cost provision has been kept for Electrical Works by State Electricity Board for providing power at the battery limits at various Locations for intermediate CP,Repeater and SV stations. For remotely located booster stations, cost of diesel driven facilities have been considered for DR.However, during implementation, feasibility for electric driven pumps depending upon availability

of grid power shall be checked and incorporated.

7.1.2 Bulk Materials, Civil and Electrical Works

Bulk and materials, i.e. Piping, Electrical Instrumentation at all terminals have been provided on percentage basis in the absence of material take-offs for the same at this stage. These percentages have been adopted from the similar projects being executed.

Cost of the civil and electrical works has also been estimated on the similar lines. Pipeline, ROU Compensation A 30M wide right-of-use is proposed to be acquired along entire route of ROU the pipeline. Compensation at 10% of the cost of the land has been provided in addition to crop compensation for one season.

7.1.3 Route Survey and Investigation

A suitable provision has been made for various surveys and soil investigations based on" the available cost data. Rajamandary, Amravati, Hyderabad 36"Hyderabad to Pandarpur, Mumbai Route Survey & Soil Inv (Incl. Route survey, cadastral survey, soil resistivity, soil investigation, etc)

7.1.4 Line Pipe

Line pipe sizes and specifications required for various sections of Pipeline as mentioned below have been considered and cost estimate for the same has been prepared based on the available cost data.

Rajmundry -Amravati	227Kms
Amravati- Hyderabad	227Kms
Hyderabad- Pandarpur	325Kms
Pandarpur- Mumbai	325Kms
TOTAL	1105 Kms

7.1.5 Line Materials

Line materials such as Valves, Fittings, Insulating Joints, etc., have been estimated on percentage basis.

7.1.6 Coating & Wrapping

The underground pipeline is proposed to be coated with 3-layer PE coating and its estimated cost has been included.

7.1.7 Laying of Pipeline

Since no terrain details are available at this stage, laying cost has been estimated considering an average rate based on the current available data. Provision has been kept for river crossing by HDD method for the following river crossing:

-Krishna River	1000	M
-bhima River	800	M
-lake	600	M

For any Line Size

Cost of pipeline laying = Pipeline laying, Conventional

of any Line Size Welding (Manual/Semi-Auto)

OR

Pipeline laying: Automatic Welding (Activities from pipe transp.from dumpsite to hydrotest after backfill)

+

*Adds on for balance pipeline laying work(select soil, concrete coat, bank stabilization, P/L markers, line preservation by inhibitor/N_2, swabbing etc)

+

Major water crossings (if applicable)

(Rivers by open cut method or Rivers by HDD* cut method)

+

Cased crossing by Boring (if applicable)

7.1.8 Cathodic Protection

The cost of the cathodic protection has been estimated based on the available cost data for the impressed current cathodic protection system considering 92 Nos.CP stations along the. Pipeline alignment.

Cost of Cathodic Protection = Rate (RS/M2) of Pipe Surface area

7.1.9 Telecom & SCADA System

The cost of the *Telecom* and SCADA system has been estimated based on the cost data available for the similar jobs being executed.

Cost of Telecom = OFC based Telecom System (fixed cost and variable cost)

+

HDPE Silicore Ducts(based on lakhs/Km)

Note: "Includes cost of OFC & Access. for upto 12 fibre OFC.

For above 12 fibre add as below:

- For 24 Fibre OFC add Rs 0.50 Lakh/Km over above
- For 48 Fibre OFC add Rs 1.50 Lakh/Km over above

Cost of SCADA System = (a) Hardware (Equipment) [

1) SMCS (Generally 1 no, either at Despatch or Receving Stn.)

+

2) RWS ((Every compres stn. & either at Receving or Despatch stn Where SMCS is not there) (fixed cost)]

+

(b) Software

+

(c) Other associated equip. like RTU, installation mati. Installation, Testing & Commissioning. (Variable (Rs Lakh / Km) for entire Pipeline length)]

7.1.10 Land & Land Development

Land areas required to be acquired and the land acquisition rate considered for various terminals are as under:

Rajmundry	2.5 Ha	Rs. 2.5lakhs/acre
Amravati	4.0 Ha each	Rs. 3 lakhs/acre
Hyderabad	4.0 Ha each	Rs. 3 lakhs/acre
Pandarpur,	4.0 Ha each	Rs. 3 lakhs/acre
Mumbai	2.5 Ha	Rs. 2.5lakhs/acre
ROU		Rs. 5 lakhs/acre

Cost of land development has been included on lump sum basis based on the available cost data available.

7.1.11 SV Stations:

The cost of the SV Stations has been estimated based on the available cost data as given below

Cost of SV Stations = Rate, (Rs Lakh/Stn)

(FX +IC+SC)

7.2 Indirect Costs

Indirect costs like ocean freight, custom duty, excise, sales tax, inland handling and transportation has been estimated at the prevailing rates given below and have been included in the cost estimates separately.

Ocean freight	@ 10% of FOB cost
Custom duty	@ 37.5% of ClF cost
Port handling	@ 2% of FOB Cost
Excise duty	@ 15% of Ex-works cost
Inland freight	@ 4%
Central sales tax	@ 10% for line pipe
Insurance	@ 5% for other items @ 1%
Works contract tax	@ 4%

Line Engineering fee & Owner's Management Expenses

It *is* presumed that the work of detailed engineering, procurement and construction supervision will be entrusted to a consultant. Consultant's estimated fee has been included.

RIL's in-house management cost towards and other administrative salaries, wages expenses like rent, office travel, communication, establishment at various construction sites specially assigned for this project have been included.

7.3 Contingencies

A contingency *provision* of 5% has been made in the cost estimate as advised by RIL(company which is interested in construction of pipeline)

7.4 Financing Charges

Interest rates have been assumed @ 15% and 10% per annum on Indian Rupee and foreign long term loans respectively. Debt/Equity ratio of 3.1 has been considered; and it is assumed that both will be running concurrently.

7.5 WORKING CAPITAL MARGIN

Margin money for the working capital has been based on the following:

NG hold up in pipes @ Rs. /MMSCM Accounts receivable 20 days. Spares, water, power and salaries.

7.6 EXCHANGE RATES

Following exchange rate have been considered:

1 US$	= Rs. 45.63
1 UK Pound	= Rs. 53.11
1 DM	= Rs.22.86
1 FF	= Rs.6.75
1 ITL Lira	= Rs.0226

7.7 TOWNSHIP

Cost of township for 230 technical personnel has been estimated @ Rs. 10 lakh per personnel.

7.8 Exclusions

The cost estimates exclude the following:

All storage and Marketing terminal facilities at Escalation cost,tap off station.

7.9 Operating Cost Estimates

Annual operating costs have been estimated for the project life of 35years.Basis, Basic cost parameters adopted for working out the operating cost have been assumed as under:

i)Power Cost	Rs. 2.25 per KWH
ii) Water	Rs. 1. 301M^3
iii) Diesel	Rs. 8000/MT
iv) Annual Repair &Maintenance	
Pipeline	1% of Pipeline cost
Compressor station	3% of Equipment Cost, Bldg&
civil work	2.5% of cost
General items	0.5%
Telecom & scada	3%
V) Insurance	: 0.12% for Pipeline
	: 0.14% for dispatch terminal
vi) Salaries and Wages	Rs. 5.0 lakhs (average) per person per annum
Vii) Manpower requirement	230 technical personnel
viii) Operating Hours	8000 / year

The operating cost estimate is estimated as Rs 58.09 crores

For the intervening years, the increase in the pipeline throughput has been considered on the straight line growth basis.

7.9.1 Sensitivity Analysis

Sensitivity analysis for pipeline transportation cost of NG with respect to variation in capital cost, revenue and operating cost has been carried out. The results are summarised in Tables.

7.10 Pay Back Period

The pay back period works out to be 10.25 years.

CHAPTER 8
Effect on Environmental

8.1 General

The pipeline mode has been found to be superior in comparison to the other modes of transportation, viz., Rail and Road, because of its inherent advantages of being environmental friendly. In addition ,the pipeline transportation offers lower energy consumption per unit of product throughput ,lower operating cost ,minimal product loss during transit, which is nil with pipeline transportation vis-a-vis 0.3%in case of transportation by rail and much higher in case of transportation by road, reduced emission ,more reliability ,etc .In order to ensure safe operation of the pipeline system, RIL are carrying out Environmental Impact Assessment as well as Risk Assessment Studies and its recommendations will be implemented during the execution and operations of the project.

Likely impact of the project on environment during construction and operation phase has been briefly discussed in the succeeding paragraphs.

8.2 Impact on Topography

The proposed pipeline route has been selected avoiding, as far as possible, passing through any built-up areas, residential areas in towns/villages, mining, reserved forest and other prohibited areas.

The pipeline will however cross certain major rivers, highway and forest areas and these cannot be altogether avoided. Actions are being initiated by RIL to obtain necessary permission from the State and other concerned authorities for carrying out pipe laying.

In order to minimize impact on forest land, the proposed pipeline alignment has been chosen so as to acquire minimum area through forest. The width of ROU to be acquired for laying the pipeline through forest area has been reduced from 30 Metres to 10-15 Metres. The pipeline will be laid in a trench and buried

approximately 1Metre below ground level except at major River crossings, where it will be buried 1.5 to 2.0 Metre below the scour level of the river .After the pipeline laying the topography of the terrain will be restored to its original condition including farming and planting of trees wherever it is required to be cut during the construction stage.

Construction of the proposed pipeline will, therefore, have negligible impact on the intervening terrain all along the pipeline alignment.

8.4 Water Pollution

Some amount of oily waste water along with dirt, etc., is expected to be generated at the despatch terminal s tap-off stations from floor washings at pump houses, filter separators, pig launching/receiving barrels, etc. This effluent will be very small in quantity and provision will be made for its proper disposal through the existing/future effluent treatment and disposal facilities 0f the terminals. RIL will arrange necessary approvals, if necessary, from the concerned State Pollution Control Boards in this regard. Discharges from drain/depressurization valves located on the cross-country portion of the pipeline will be routed to mobile flare system. Water pollution, therefore, is not expected.

8.5 Line Leak/Burst

The pipeline will be hydrotested before commissioning as per provisions of ANSI 31.4B Code as well as OISD stipulations.

The pipeline will also be protected against external. Corrosion by means of 3-layer. Polyethylene coating and a suitable Cathodic Protection (CP) system. With proper maintenance and monitoring of the system, chances of a sudden leak or burst in the pipeline will be very remote. However, in the unlikely event of a line burst, the impact on soil and atmosphere could be substantial as LPG is highly inflammable and explosive in nature To minimise the impact of such an

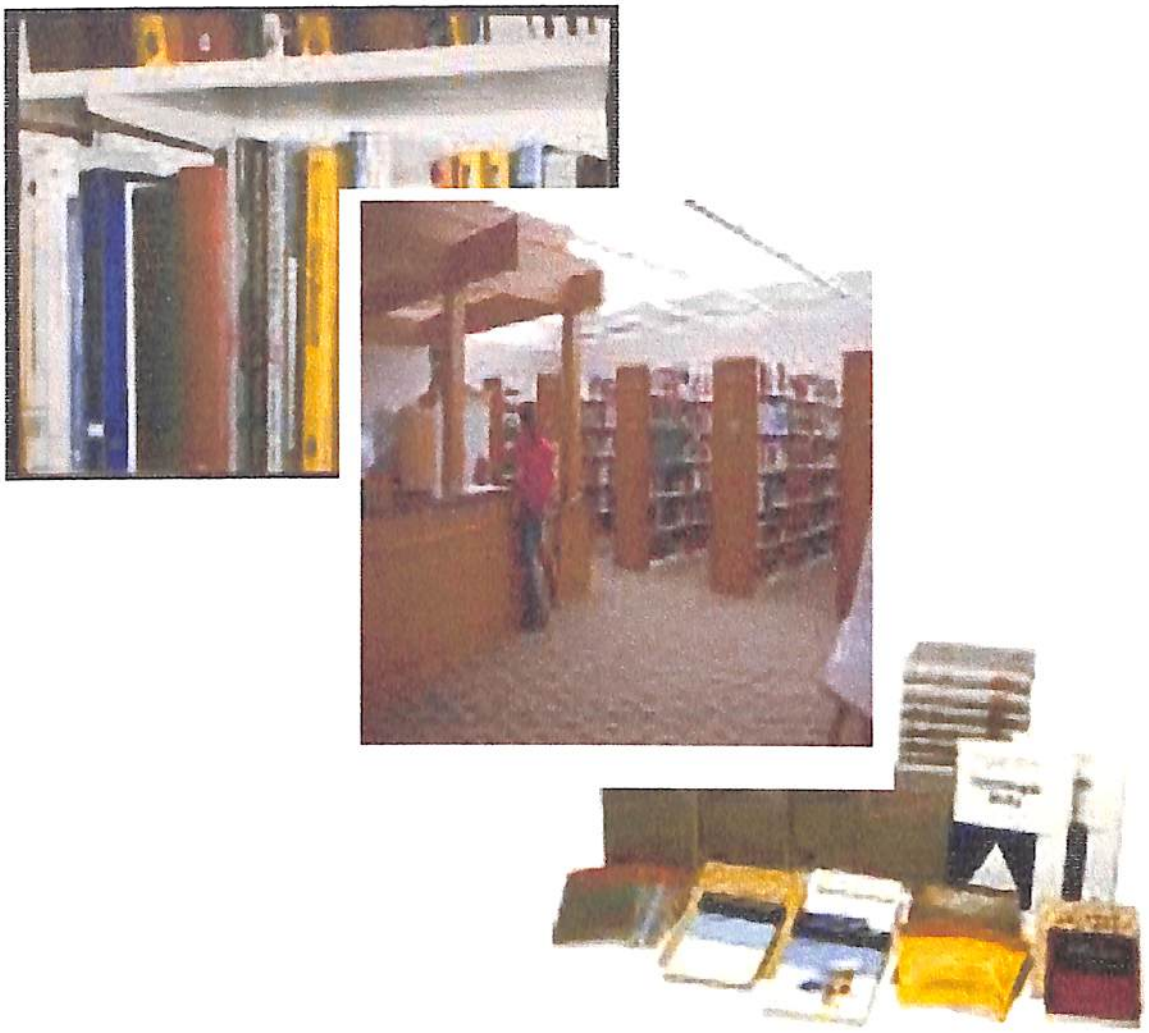
eventuality, state-of-the-art leak detection system operated through SCADA will be provided. This will ensure instantaneous detection of a burst and near-immediate detection of leak and control of the spillage will be achieved by isolating the affected section by shutting down the remotely operated sectionalizing valves. Any malfunctioning/mishap would De iIT_8diatelY detected by continuous monitoring of various critical operating parameters, like, flow, temperature, pressure, etc., through suitable instrumentation connected to the SCADA system. Necessary instruments wi11 be provided to ensure automatic shut-off of the pumps in the event of a sudden fall in line pressure.

Conclusion

Using GIS for pipeline route selection the cost of pipeline survey is reduced by 15-20% The cost of pipeline is Pay back period is calculated as 10.25 years

As Gail is only company in India playing a monopoly in Transmission and Distribution of natural gas .From 2010 India will be consuming 240MMSCMD of natural gas from which 1/3 will be from LNG and remaining will be from domestic production .

This type of study will aid in **Develop safe, environmentally responsible, cost-effective and reliable solutions for the design, construction, and operation of energy pipelines**



References

1. **PROJECT: Sakhalin Energy Investment Company Ltd.**
   Alternatives Offshore and Onshore Pipelines Route Selection Report.
2. **PROJECT:** Empire State Newsprint Projects -Gas Transmission Line,Rensselaer, Schodack and East Greenbush, NY
3. **PROJECT:** Sheberghan to Kabul Gas Pipeline and Generating Plant(Ministry of Mines and Industries)
4. **PROJECT**: Pipeline Design, Construction & Operation Technical Committee
5. **PROJECT:** TRANSCONTINENTAL GAS PIPELINES Investment Risks and Frameworks
6. **PROJECT:** LPG pipeline report from kandala to Piyala
7. **PROJECT:** Remote Sensing and GIS data from Rolta
8. **PROJECT:** Pipelines in the Middle East
9. **PROJECT:** The Northeast Asia Natural Gas Pipeline Network
10. **PROJECT**: Diffusion, Costs and Learning in the Development Of International Gas Transmission Lines.

TABLE: 9

TOTAL CAPITAL COST OF PIPELINE

ALL COSTS ARE IN LAKHS		Fx	Rs	Sc	TOTAL
SNO	**DESCRIPTION**				
1	PLANT AND MACHINERY	303212	10295	38854	
	PIPELINE	34	297	179	357275
1.1		149 *3	893 * 3	425 *3	510
1.2	**DESPATCH STATION**	12	36	129	
1.3	**INTERMEDIATE COMPSTATION**				4401
1.4	**RECEVING STATION**				177
	SUB-TOTAL (1)				362363
2	ENGINEERING COSTS		5867		5867
2.1	**BASIC ENGG., DETAIL ENGG., PROCUREMENT, CONSTRUCTION SUPERVISION & PROJECT MANAGEMENT**				
					368230
3	SITE RELATED COSTS			2300	2300
	TOWNSHIP				
					370530
4	OTHERS		2934		2934
4.1	**OWNER'S CONST. PERIOD EXPENSES**				
4.2	**START UP & COMMISSIONING EXPENSES**		60		60
					373464
5	**CONTINGENCY**				22137
	SUB-TOTAL (1 TO 5)				395601
6	**MARGIN MONEY ON WORKING CAPITAL**				
	SUB-TOTAL (1 TO 6)				
7	**FINANCING CHARGES**				not available
	TOTAL				**395601**

TABLE: 10

CAPITAL COST ESTIMATION OF DESPATCH TERMINAL (RAJAMANDARY) NG PIPELINE FOR RIL

S.NO	DSECRIPTION	ALL COST IN RS LAKHS								DESIGN ENGINEERING COMPANY
		PHASE I				PHASE II				JOBNO
		FX	RS	SC	TOTAL	FX	RS	SC	TOTAL	
										PROJECT NG PIPELINE
A	DESPATCH TERMINAL									
1	MAINLINE COMPRS(I+1)		120		120					UNIT
2	FILTER (11+1)		12		12					CONSULTANT
3	METERING FACILITY	20			20					CLIENT
4	PIG LAUNCHER	4			4					
										TYPES OF ESTMATE
										PRELIMINARY
										DETAIL
										ANY OTHER
	SUB TOTAL	24	132		156					ESTIMATE VALIDITY
B	BULK MATERIAL									
1	PIPING	6	31		37					
2	ELECTRICAL		59		59					NOTES
3	INSTRUMENTATION	1	21		22					
										1 US 3 = Rs.35.02
										1 PS = Rs.53.11
										1 FF = Rs 6.75
										1 DM = Rs.22.86
										1 ITL = Rs.0.0226
	SUB TOTAL	31	243		274					CUSTOMS DUTY 37.50%
C	SPARES	3	12		15					EXCISE DUTY 15.00%
										SALES TAX 4.00%
										WORKS TAX 4.00%
										PROJECT MANAGER
	SUB TOTAL	34	255		289					
D	ERECN			30	30					
E	LAND			25	25					COST ENGINEERING DEPTT
F	CIVIL WORKS			53	53					
G	LAND DEVELOPEMENT			60	60					
	SUB TOTAL	34	255	168	457					PREPARED
H	INSULATION AND PAINTING			4	4					REVIEWED
										APPROVED
	SUB TOTAL	34	255	172	461					
1)	INDIRECT COSTS									
I	OCEAN FRT&C.D									SUMMARY
II	PORT HANDLING &INLAND FRT									DATE
III	EXCISE &SALES TAX		38		38					REVISION
IV	INSURANCE		4		4					
V	WORKS CONTRACT TAX			7	7					
	SUB TOTAL	34	297	179	510					
	TOTAL A TO H 1									SHEET OF

TABLE: 11

CAPITAL COST ESTIMATION OF INTERMEDIATE DESPATCH TERMINAL (AMRAVATI) NG PIPELINE FOR RIL

S.NO	DSECRIPTION	ALL COST IN RS LAKHS								DESIGN ENGINEERING COMPANY
		PHASE I				PHASE II				JOBNO
		FX	RS	SC	TOTAL	FX	RS	SC	TOTAL	PROJECT NG PIPELINE
A	INT .DESPATCH									
1	TERMINAL		320		320					UNIT
2	MAINLINE COMPRS(I+1)		36		36					CONSULTANT
3	CARTRIDGE FILTER (11+1)	100			100					CLIENT
4	METERING FACILITY	15			15					
	PIG LAUNCHER									TYPES OF ESTMATE
										PRELIMINARY
										DETAIL
										ANY OTHER
	SUB TOTAL	115	356		471					ESTIMATE VALIDITY
B	BULK MATERIAL									
1	PIPING	18	100		118					NOTES
2	ELECTRICAL		189		189					
3	INSTRUMENTATION	4	67		71					1 US 3 = Rs.35.02
										1 PS = Rs.53.11
										1 FF = Rs 6.75
										1 DM = Rs.22.86
										1 ITL = Rs.0.0226
	SUB TOTAL	137	712		849					CUSTOMS DUTY 37.50%
C	SPARES	12	37		49					EXCISE DUTY 15.00%
										SALES TAX 4.00%
										WORKS TAX 4.00%
										PROJECT MANAGER
	SUB TOTAL	149	749		898					COST ENGINEERING DEPTT
D	ERECN			96	96					
E	LAND			35	35					
F	CIVIL WORKS			170	170					
G	LAND DEVELOPMENT			96	96					
	SUB TOTAL	149	749	397	1295					PREPARED
H	INSULATION AND PAINTING			12	12					REVIEWED
										APPROVED
	SUB TOTAL	149	749	409	1307					
1)	INDIRECT COSTS									SUMMARY
I	OCEAN FRT&C.D									DATE
II	PORT HANDLING									REVISION
III	&INLAND FRT		142		142					
IV	EXCISE &SALES TAX		2		2					
V	INSURANCE			16	16					
	WORKS CONTRACT TAX									
	SUB TOTAL	149	893	425	1467					
	TOTAL A TO H.....1									SHEET OF

TABLE: 12

CAPITAL COST ESTIMATION OF INTERMEDIATE DESPATCH TERMINAL (HYDERABAD) NG PIPELINE FOR RIL

ALL COST IN RS LAKHS

S.NO	DSECRIPTION	PHASE I FX	PHASE I RS	PHASE I SC	PHASE I TOTAL	PHASE II FX	PHASE II RS	PHASE II SC	PHASE II TOTAL
A	INT .DESPATCH								
1	TERMINAL		320		320				
2	MAINLINE COMPRS(I+ 1)		36		36				
3	CARTRIDGE FILTER (11+ 1)	100			100				
4	METERING FACILITY	15			15				
	PIG LAUNCHER								
	SUB TOTAL	115	356		471				
B	BULK MATERIAL								
1	PIPING	18	100		118				
2	ELECTRICAL		189		189				
3	INSTRUMENTATION	4	67		71				
	SUB TOTAL	137	712		849				
C	SPARES	12	37		49				
	SUB TOTAL	149	749		898				
D	ERECN			96	96				
E	LAND			35	35				
F	CIVIL WORKS			170	170				
G	LAND DEVELOPMENT			96	96				
	SUB TOTAL	149	749	397	1295				
H	INSULATION AND PAINTING			12	12				
	SUB TOTAL	149	749	409	1307				
1)	INDIRECT COSTS								
I	OCEAN FRT&C.D								
II	PORT HANDLING								
III	&INLAND FRT		142		142				
IV	EXCISE &SALES TAX		2		2				
V	INSURANCE			16	16				
	WORKS CONTRACT TAX								
	SUB TOTAL	149	893	425	1467				
	TOTAL A TO H 1								

DESIGN ENGINEERING COMPANY

JOBNO

PROJECT NG PIPELINE

UNIT
CONSULTANT
CLIENT

TYPES OF ESTMATE

PRELIMINARY
DETAIL
ANY OTHER

ESTIMATE VALIDITY

NOTES

1 US 3 = Rs.35.02
1 PS = Rs.53.11
1 FF = Rs 6.75
1 DM = Rs.22.86
1 ITL = Rs.0.0226

CUSTOMS DUTY 37.50%
EXCISE DUTY 15.00%
SALES TAX 4.00%
WORKS TAX 4.00%

PROJECT MANAGER

COST ENGINEERING DEPTT

PREPARED
REVIEWED
APPROVED

SUMMARY
DATE
REVISION

SHEET OF

TABLE: 13

CAPITAL COST ESTIMATION OF INTERMEDIATE DESPATCH TERMINAL (PANDARPUR) NG PIPELINE FOR RIL

ALL COST IN RS LAKHS

DESIGN ENGINEERING COMPANY

S.NO	DSECRIPTION	PHASE I FX	RS	SC	TOTAL	PHASE II FX	RS	SC	TOTAL
A	INT .DESPATCH								
1	TERMINAL		320		320				
2	MAINLINE COMPRS(I+ 1)		36		36				
3	CARTRIDGE FILTER (1I+1)	100			100				
4	METERING FACILITY	15			15				
	PIG LAUNCHER								
	SUB TOTAL	115	356		471				
B	BULK MATERIAL								
1	PIPING	18	100		118				
2	ELECTRICAL		189		189				
3	INSTRUMENTATION	4	67		71				
	SUB TOTAL	137	712		849				
C	SPARES	12	37		49				
	SUB TOTAL	149	749		898				
D	ERECN			96	96				
E	LAND			35	35				
F	CIVIL WORKS			170	170				
G	LAND DEVELOPMENT			96	96				
	SUB TOTAL	149	749	397	1295				
H	INSULATION AND PAINTING			12	12				
	SUB TOTAL	149	749	409	1307				
1)	INDIRECT COSTS								
I	OCEAN FRT&C.D								
II	PORT HANDLING								
III	&INLAND FRT		142		142				
IV	EXCISE &SALES TAX		2		2				
V	INSURANCE			16	16				
	WORKS CONTRACT TAX								
	SUB TOTAL	149	893	425	1467				
	TOTAL A TO H I								

JOBNO

PROJECT NG PIPELINE

UNIT
CONSULTANT
CLIENT

TYPES OF ESTMATE
PRELIMINARY
DETAIL
ANY OTHER

ESTIMATE VALIDITY

NOTES

1 US 3 = Rs.35.02
1 PS = Rs.53.11
1 FF = Rs 6.75
1 DM = Rs.22.86
1 ITL = Rs.0.0226

CUSTOMS DUTY 37.50%
EXCISE DUTY 15.00%
SALES TAX 4.00%
WORKS TAX 4.00%

PROJECT MANAGER

COST ENGINEERING DEPTT

PREPARED
REVIEWED
APPROVED

SUMMARY
DATE
REVISION

SHEET OF

TABLE: 14

CAPITAL COST ESTIMATION OF RECEVING TERMINAL (MUMBAI) NG PIPELINE FOR RIL

S.NO	DSECRIPTION	ALL COST IN RS LAKHS								DESIGN ENGINEERING COMPANY
		PHASE I FX	RS	SC	TOTAL	PHASE II FX	RS	SC	TOTAL	JOBNO PROJECT
A	RECE DESPATCH TERMINAL	EXCLUDED TO BE CONSIDERED BY MARKETING COMPANIES								UNIT NG PIPELINE
1										CONSULTANT
2	MAINLINE COMPRS(I+ 1)									CLIENT
3	METERING FACILITY	10			10					
	PIG LAUNCHER / RECEIVER									TYPES OF ESTMATE
										PRELIMINARY
										DETAIL
										ANY OTHER
	SUB TOTAL				10					
B	BULK MATERIAL									ESTIMATE VALIDITY
1	PIPING	2	11		13					
2	ELECTRICAL		9		9					NOTES
3	INSTRUMENTATION	0	8		8					
										1 US 3 = Rs.35.02
										1 PS = Rs.53.11
										1 FF = Rs 6.75
										1 DM = Rs.22.86
										1 ITL = Rs.0.0226
	SUB TOTAL	12	28		40					
C	SPARES		9	1	10					CUSTOMS DUTY 37.50%
										EXCISE DUTY 15.00%
										SALES TAX 4.00%
										WORKS TAX 4.00%
										PROJECT MANAGER
	SUB TOTAL	12	37	1	50					COST ENGINEERING DEPTT
D	ERECN			10	10					
E	LAND			30	30					
F	CIVIL WORKS			23	23					
G	LAND DEVELOPMENT			48	48					
	SUB TOTAL	12	37	122	161					PREPARED
H	INSULATION AND PAINTING			2	2					REVIEWED
										APPROVED
	SUB TOTAL	12	37	124	163					
1)	INDIRECT COSTS									
I	OCEAN FRT&C.D									SUMMARY
II	PORT HANDLING									DATE
III	&INLAND FRT		8		8					REVISION
IV	EXCISE &SALES TAX		1		1					
V	INSURANCE			5	5					
	WORKS CONTRACT TAX									
	SUB TOTAL	12	36	129	177					
	TOTAL A TO H I									SHEET OF

TABLE: 15

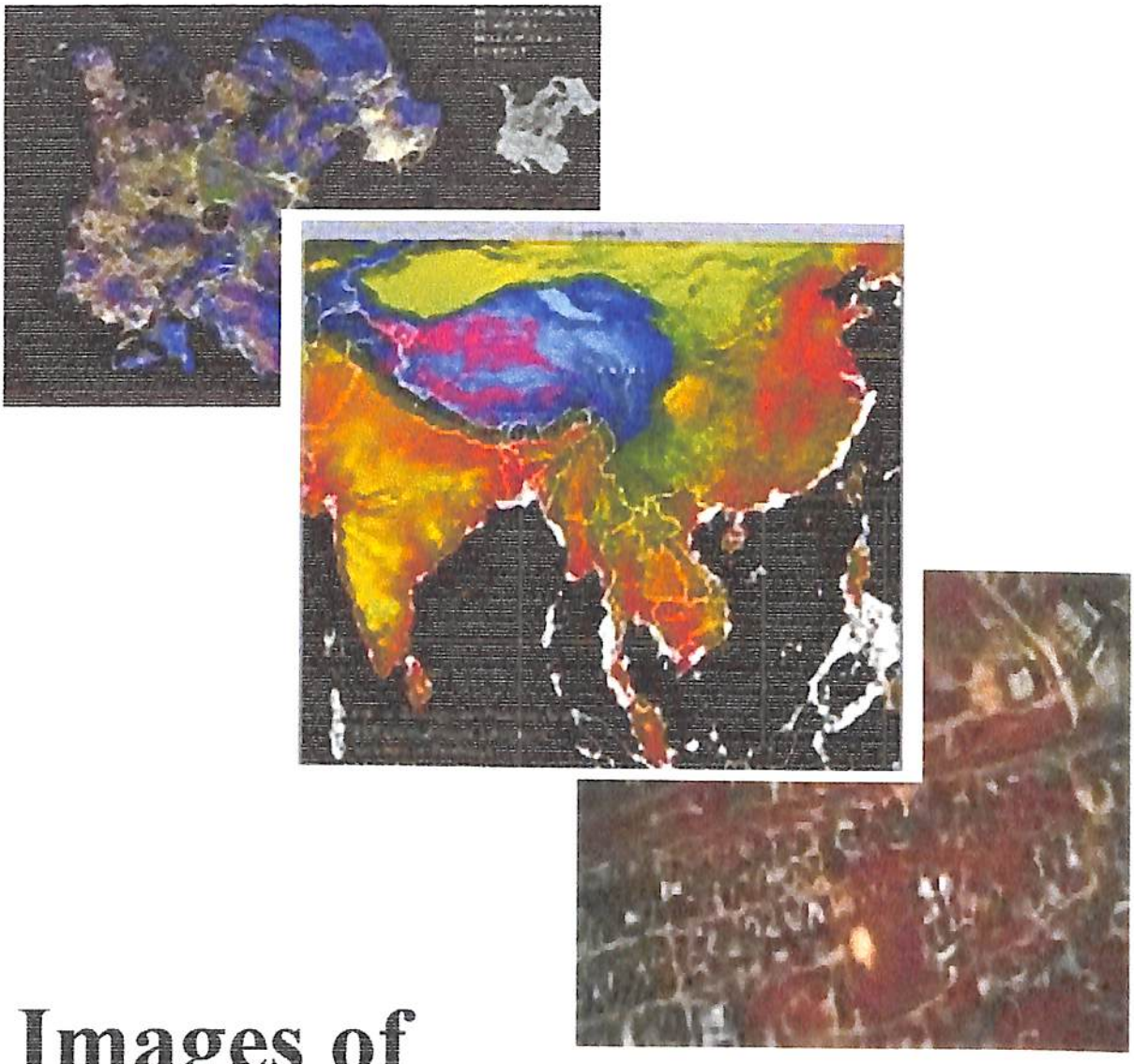
CAPITAL COST OF NG PIPELINE (RIL)

S.NO	DSECRIPTION	ALL COST IN RS LAKHS								DESIGN ENGINEERING COMPANY	
		PHASE I				PHASE II				JOBNO	
		FX	RS	SC	TOTAL	FX	RS	SC	TOTAL	PROJECT	NG PIPELINE
1	SUREVY & SOIL INVESTIGATION			446	446					UNIT CONSULTANT CLIENT	
2	ROW COMPENSATION			2210	2210						
3	LINE PIPE	293647			293647						
4	LINE MATERIAL	10000	1588		11588					TYPES OF ESTMATE	
5	COAT&WRAP			15513	15513					PRELIMINARY DETAIL ANY OTHER	
6	LAYING			17492	17492						
7	HDD CROSSING(NO.S)	-		1008	1008					ESTIMATE VALIDITY	
8	CATHODIC PROTECTION			691							
9	TELECOM/SCADA	1845	6630		9166					NOTES	
10	SECTIONALISING VALVES	2720			2720					1 US $ = Rs.35.02 1 PS = Rs.53.11 1 FF = Rs 6.75 1 DM = Rs.22.86 1 ITL = Rs.0.0226	
	SUB TOTAL	303212	8218	37360	353790					CUSTOMS DUTY 37.50% EXCISE DUTY 15.00% SALES TAX 4.00% WORKS TAX 4.00%	
11)	INDIRECT COSTS										
I	OCEAN FRT&C.D									PROJECT MANAGER	
II	PORT HANDLING &INLAND FRT		1561		1561						
III	EXCISE &SALES TAX		426		426					COST ENGINEERING DEPTT	
IV	INSURANCE			1494	1494						
V	WORKS CONTRACT TAX									PREPARED REVIEWED APPROVED	
										SUMMARY DATE REVISION	
	SUB TOTAL	303212	10295	38854	357275					SHEET OF	
	TOTAL 1TO 11				357275						

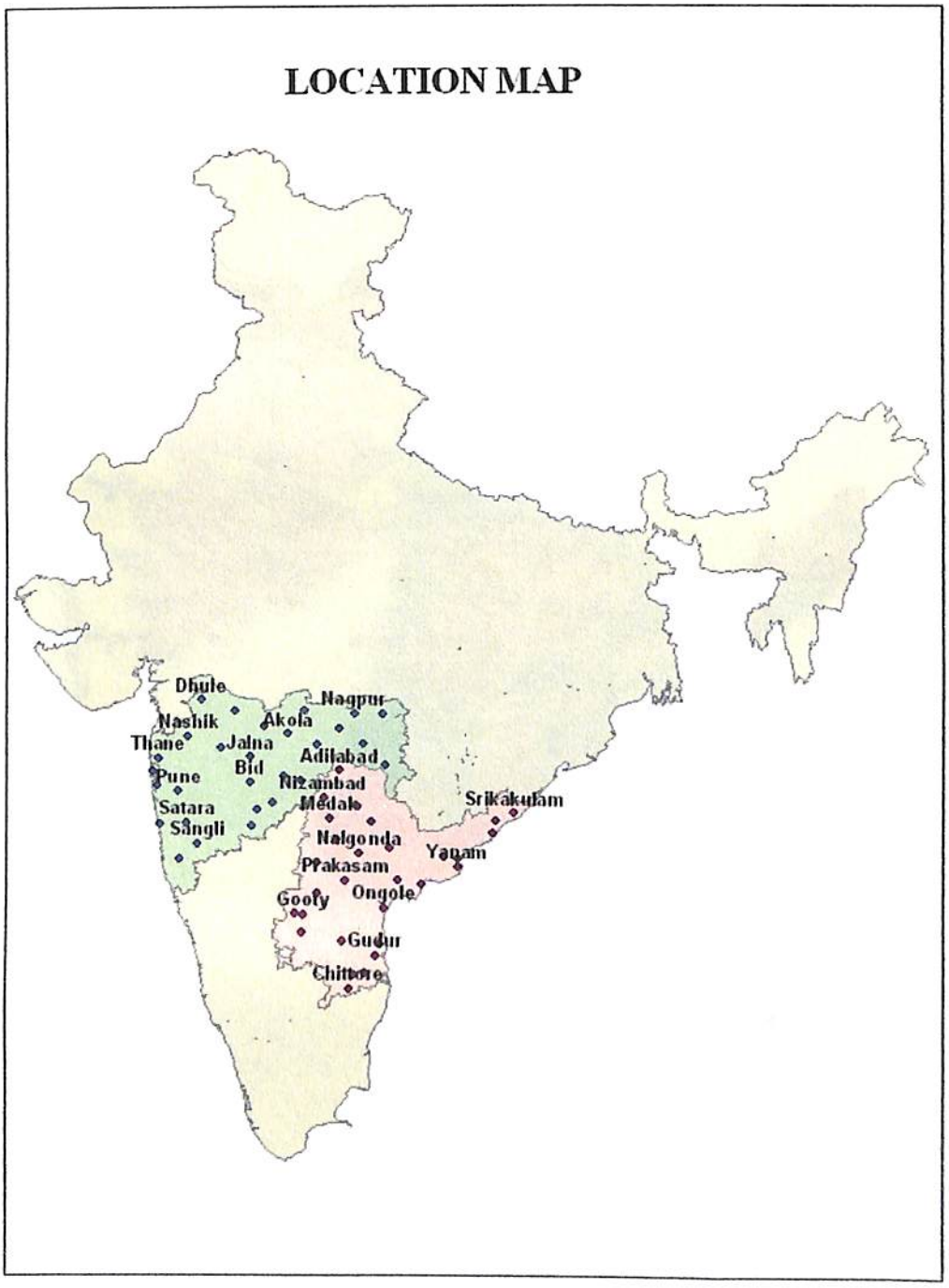
TABLE: 16

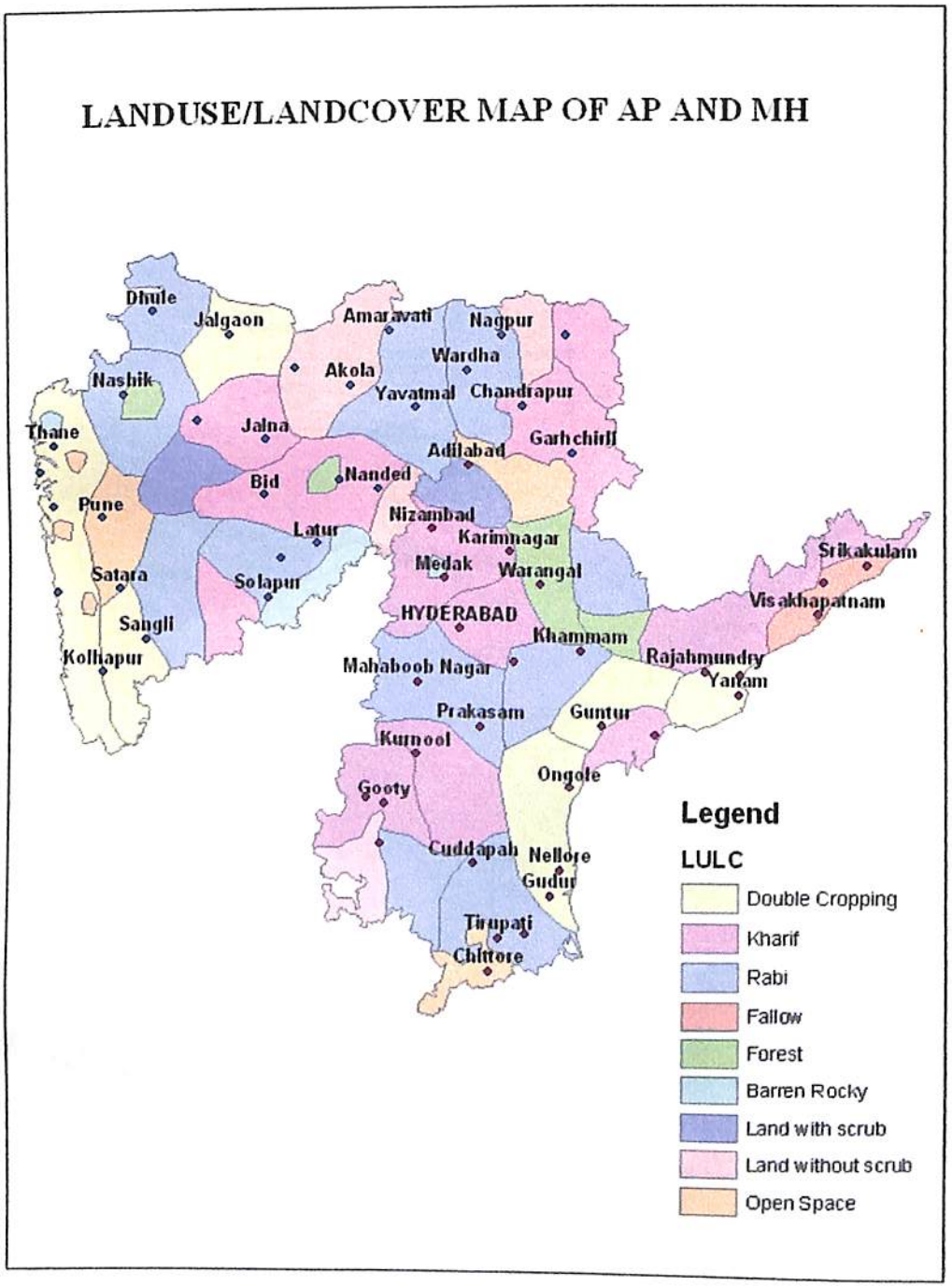
ANNUAL OPERATING COST

S.NO	DSECRIPTION	ALL COST IN RS LAKHS								DESIGN ENGINEERING COMPANY	
		PHASE I				PHASE II				JOBNO	
		UNIT	RATE RS	QTY	TOTAL	U	RATE RS	QTY	TOTAL	PROJECT	NG PIPELINE
										UNIT CONSULTANT CLIENT	
A	VARAIABLES RAW MATERIALS DESPATCH TERMINAL CORROSSION INHIBITOR									TYPES OF ESTMATE	
										PRELIMINARY DETAIL ANY OTHER	
B	SUB TOTAL UTILITIES									ESTIMATE VALIDITY	
1	POWER			10^3							
I	RAJAMANDARY	KWHR	2..25	59.25	119.5					NOTES	
II	AMRAVATI	KWHR	2..25	119.5	269						
III	HYDERABAD	KWHR	2..25	119.5	269					1 US 3 = Rs.35.02	
IV	PANDARPUR	KWHR	2..25	119.5	269					1 PS = Rs.53.11	
V	MUMBAI	KWHR	2..25	60	135					1 FF = Rs 6.75	
										1 DM = Rs.22.86	
2	WATER	M^3	1.3	15	19.5					1 ITL = Rs.0.0226	
	SUB TOTAL				989					CUSTOMS DUTY 37.50% EXCISE DUTY 15.00% SALES TAX 4.00% WORKS TAX 4.00%	
										PROJECT MANAGER	
	TOTAL VARIABLECOST				989					COST ENGINEERING DEPTT	
H	FIXED OPERATING COST									PREPARED REVIEWED APPROVED	
1)	SALARY WAGES& OH	NO	$5*10^5$	230	1150						
	REPAIR &MAINTENANCE										
I	COMPRESSOR @3%			3.0%						SUMMARY	
II	PIPELINE @1%		COST	1.0%						DATE	
III	CIVIL WORKS				14					REVISION	
IV	@2.5%				334						
	TELECOM & SCADA @3%										
	INSURANCE			.12%							
				.14%							
	TOTAL FIXED COST B				4820						
	TOTAL OPERATING COST A+B				5809					SHEET OF	
	GRAND TOTAL				5809						

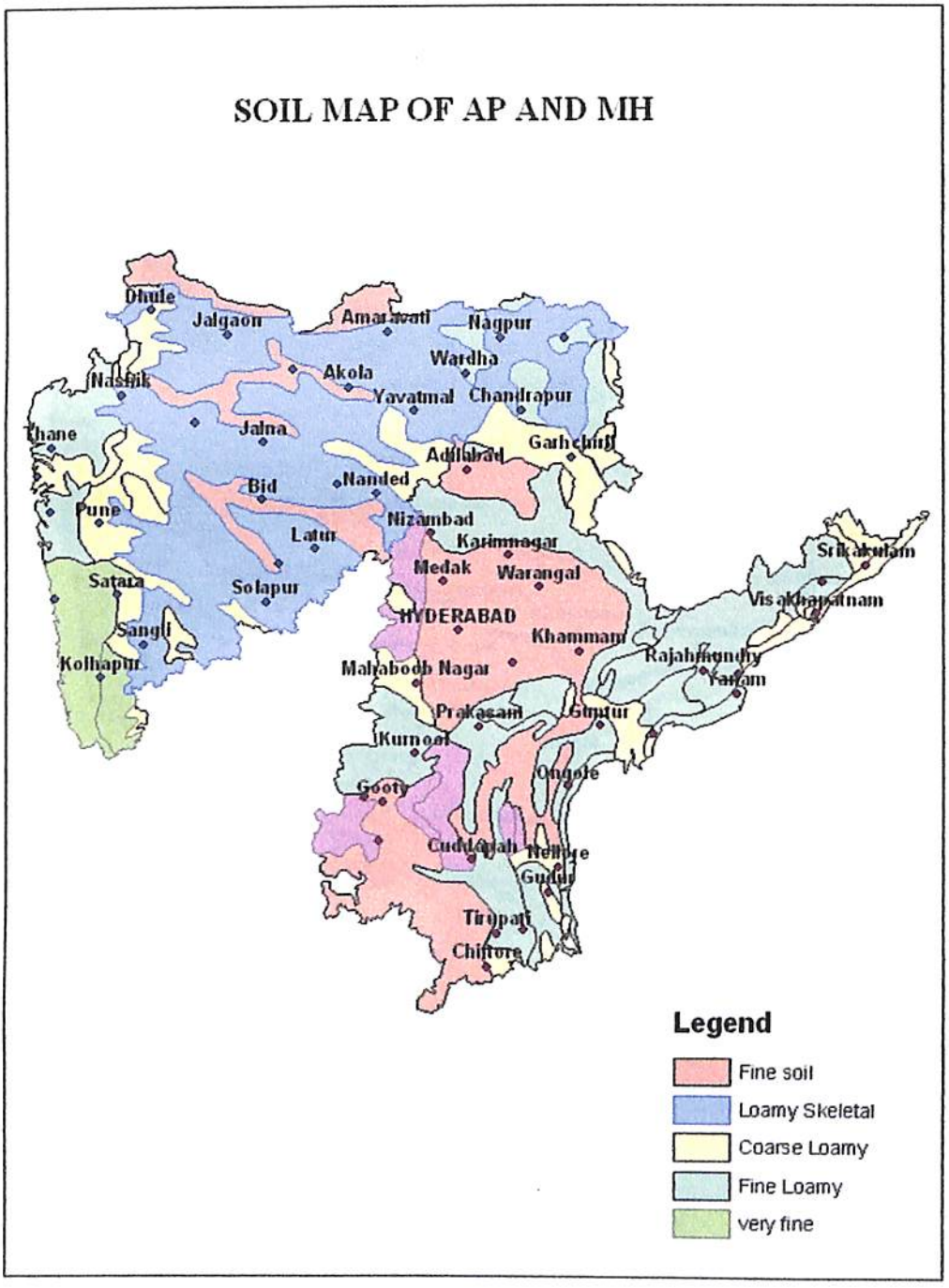


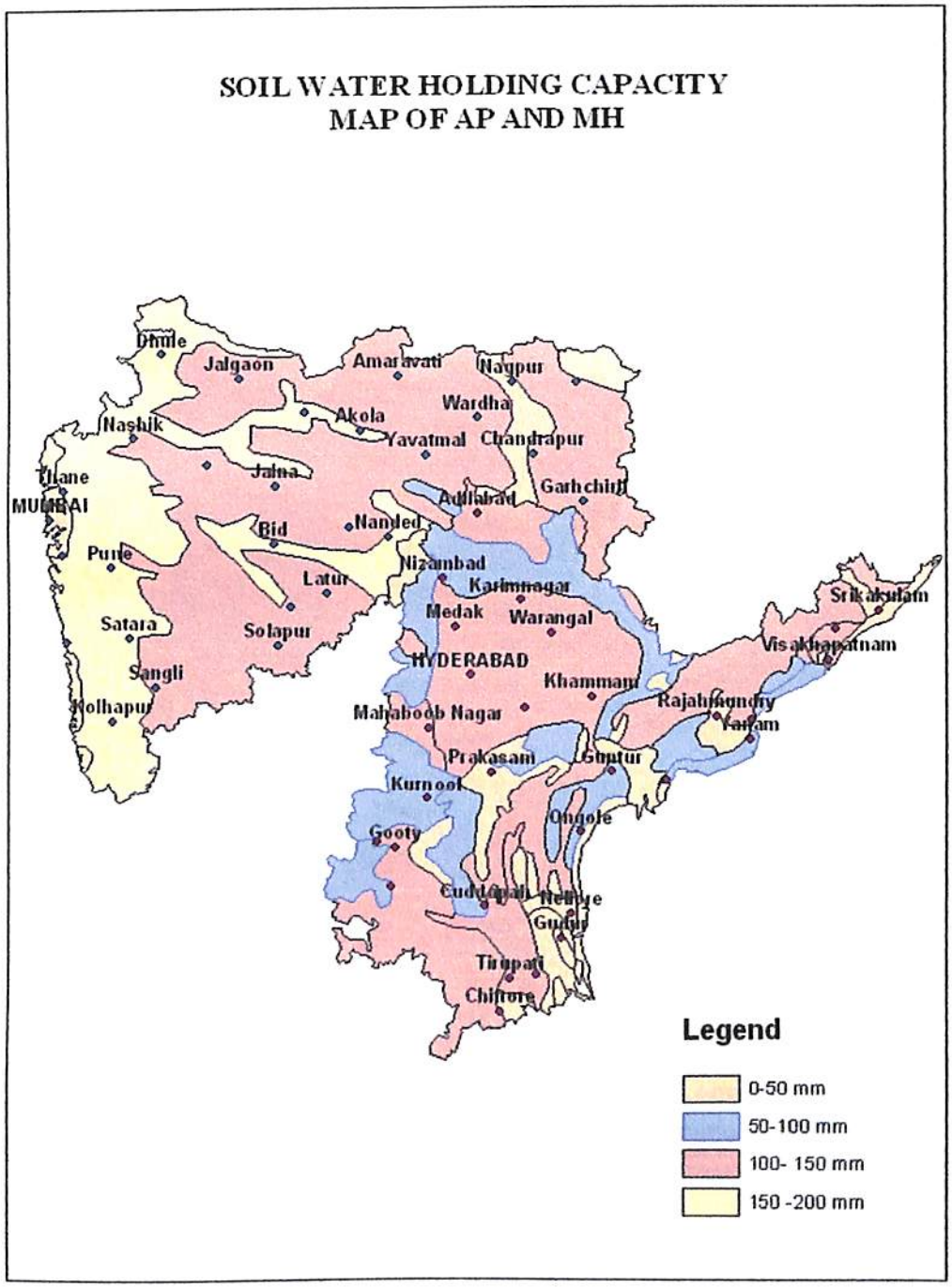
Images of Remote Sensing and GIS

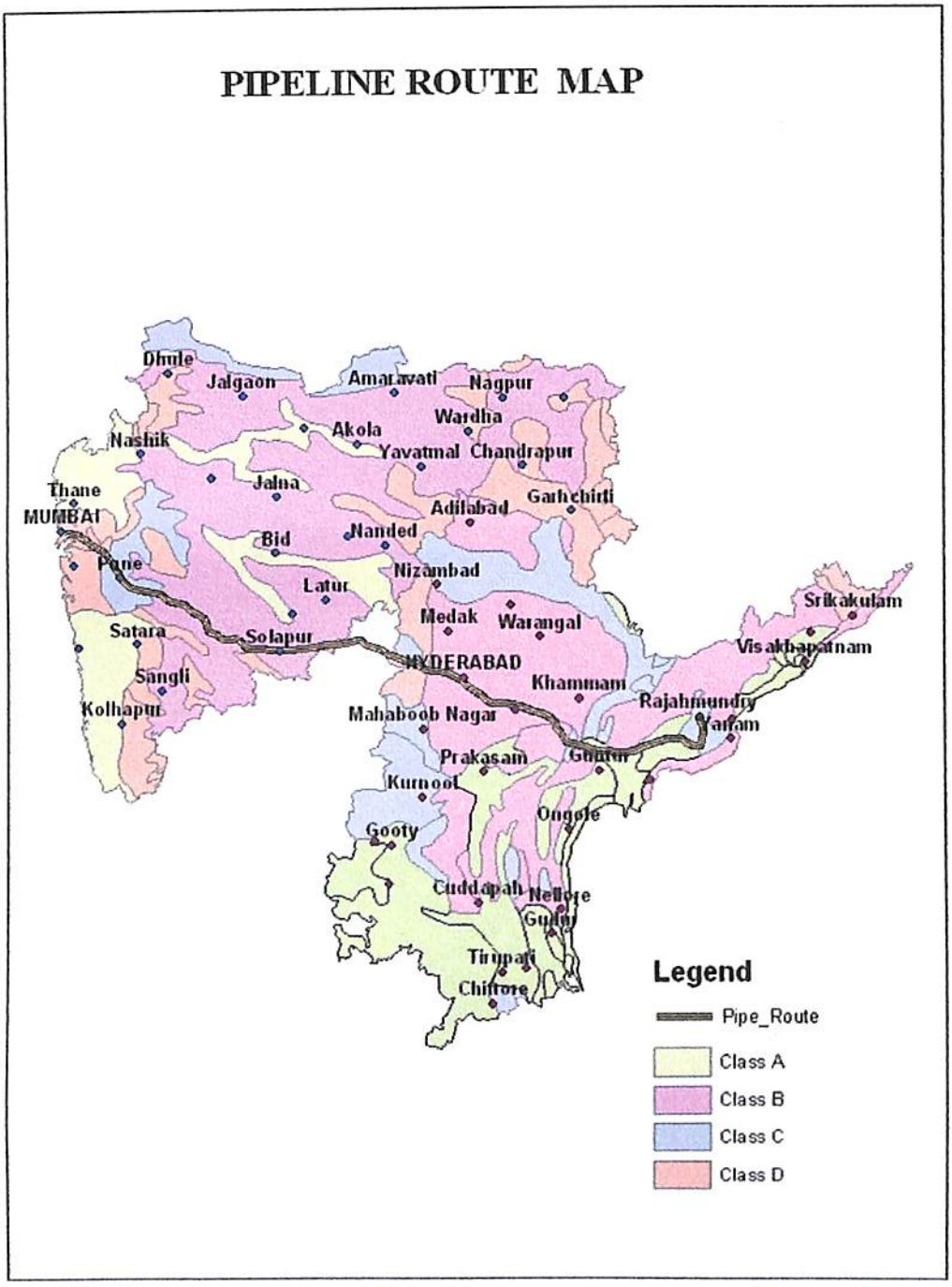

LOCATION MAP
Dhule
Nagpur
Nashik
Akola
Thane
Jalna
Adilabad
Bid
Pune
Nizambad
Medak
Satara
Srikakulam
Sangli
Nalgonda
Yanam
Prakasam
Ongole
Goofy
Gudur
Chittore


LANDUSE/LANDCOVER MAP OF AP AND MH
Dhule
Jalgaon
Amaravati
Nagpur
Wardha
Akola
Nashik
Yavatmal
Chandrapur
Jalna
Thane
Garhchirli
Adilabad
Bid
Nanded
Pune
Nizambad
Latur
Karimnagar
Srikakulam
Medak
Warangal
Satara
Solapur
Visakhapatnam
HYDERABAD
Sangli
Khammam
Kolhapur
Rajahmundry
Mahaboob Nagar
Yanam
Prakasam
Guntur
Kurnool
Ongole
Gooty
Legend
LULC
Cuddapah
Nellore
Gudur
Double Cropping
Kharif
Tirupati
Rabi
Chittore
Fallow
Forest
Barren Rocky
Land with scrub
Land without scrub
Open Space

PIPELINE ROUTE MAP


SOIL MAP OF AP AND MH
Dhule
Jalgaon
Amaravati
Nagpur
Wardha
Akola
Nashik
Yavatmal
Chandrapur
Thane
Jalna
Adilabad
Garhchiroli
Bid
Nanded
Pune
Nizambad
Latur
Karimnagar
Srikakulam
Medak
Warangal
Satara
Solapur
Visakhapatnam
HYDERABAD
Sangli
Khammam
Rajahmundry
Kolhapur
Mahabob Nagar
Kakinada
Prakasam
Guntur
Kurnool
Ongole
Gooty
Cuddapah
Nellore
Gudur
Tirupati
Chittore
Legend
Fine soil
Loamy Skeletal
Coarse Loamy
Fine Loamy
very fine


SOIL WATER HOLDING CAPACITY
MAP OF AP AND MH
Dhule
Jalgaon
Amaravati
Nagpur
Wardha
Akola
Nashik
Yavatmal
Chandrapur
Jalna
Thane
MUMBAI
Adilabad
Garhchiroli
Nanded
Bid
Pune
Nizambad
Karimnagar
Latur
Medak
Warangal
Srikakulam
Satara
Solapur
Visakhapatnam
HYDERABAD
Sangli
Khammam
Kolhapur
Rajahmundry
Mahaboob Nagar
Eluru
Prakasam
Guntur
Kurnool
Ongole
Gooty
Cuddapah
Nellore
Guntur
Tirupati
Chittore
Legend
0-50 mm
50-100 mm
100- 150 mm
150 -200 mm


PIPELINE ROUTE MAP
Dhule
Jalgaon
Amaravati
Nagpur
Wardha
Akola
Nashik
Yavatmal
Chandrapur
Jalna
Thane
MUMBAI
Adilabad
Garhchiroli
Bid
Nanded
Pune
Nizambad
Latur
Srikakulam
Medak
Warangal
Satara
Solapur
Visakhapatnam
HYDERABAD
Sangli
Khammam
Kolhapur
Rajahmundry
Mahaboob Nagar
Yanam
Prakasam
Guntur
Kurnool
Ongole
Gooty
Cuddapah
Nellore
Tirupati
Chittore
Legend
Pipe_Route
Class A
Class B
Class C
Class D