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FFS-Final Report - July 2002

Impact Assessment of HBJ Pipeline Upgradation Project, Phase III (Gas Authority of India Limited) on the Flora and Fauna

Project proponent	:	Gas Authority of India Limited
Consultant	:	Engineers India Limited
Flora – fauna study	:	Sálim Ali Centre For Ornithology & Natural History

Sálim Ali Centre For Ornithology & Natural History
Coimbatore, Tamil Nadu
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Sálim Ali Centre For Ornithology & Natural History
Coimbatore, Tamil Nadu
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LIST OF ABBREVIATIONS

EIA	-	Environmental Impact Assessment
EIL	-	Engineers India Limited
FFS	-	Flora – Fauna Study
GAIL	-	Gas Authority of India Limited
GBH	-	Girth at Breast Height
GPS	-	Global Positioning System
RoU	-	Right of Use
SACON	-	Salim Ali Centre for Ornithology & Natural History

1. INTRODUCTION

The Gas Authority of India Limited (GAIL) proposes to lay a 900km long pipeline network to transport natural gas. This line is proposed as an upgradation of the existing HBJ line, the largest gas pipeline network in the country. The pipeline passes through Madhya Pradesh, Haryana, Delhi, Rajasthan and Punjab. As with most other such pipelines, this one also will be laid at minimum of one meter below the surface in a 30m wide RoU. As per the notification of Ministry of Environment and Forests, Government of India (Anonymous 1994) it is essential to conduct Environmental Impact Assessment of such large-scale projects prior to its implementation. The assessment of the impact of the pipeline on the floral and faunal aspects, as a part of the EIA, was awarded to Sálim Ali Centre for Ornithology and Natural History (SACON), Coimbatore, an autonomous institute funded by the Ministry of Environment and Forests, Government of India. SACON, a research organization dedicated to conservation of nature and natural resources, has extensive expertise and experience in carrying out environmental impact assessments with respect to flora and fauna.

2. SCOPE

Scope of the work as per the TOR were to

i) Examine the pipeline project in the light of various forests and wildlife acts, environmental protection act and other relevant regulations/ notifications/ guidelines,

ii) Assess the baseline status of forest and wildlife of the area including flora, avifauna and aquatic life in the pipeline corridor (500m on either side) and identify endangered species if any,

iii) Assess the impact on fauna, flora and aquatic ecology due to the proposed pipeline project,

iv) Suggest an environmental management plan to mitigate the negative impacts of the pipeline,

v) Carry out cost-benefit analysis of the project with respect to the environment, and

vi) Prepare flora and fauna study report based on study and assessment as above.

3. METHODOLOGY

A field survey of the pipeline route to generate primary data on various parameters essential to address the scope of the study defined earlier forms the major part of the study. The field surveys entirely depended on the relevant photocopy (in b&w) of Survey of India maps (toposheets; scale 1:50000, some in 1:250000 scale) provided by EIL with the proposed pipeline is marked on it. The detailed field survey and the sampling points for intensive data collection were scheduled based on a preliminary examination of the route. During the preliminary examination it was felt convenient to divide the entire stretch into ten sections.

The study covers the entire stretch (Figure 1 a & b) of the pipeline route. For intensive study of the flora and fauna, sampling points were marked at an interval of approximately 15-20km along the route. Utmost care was taken so that all the sampling points taken for data collection falls within 500m of the pipeline alignment marked on the maps. Hence, the precision of the distance estimated regarding the location of sampling points, other ecologically sensitive areas such as Wildlife Sanctuaries, National Parks, with respect to the pipeline alignment largely depend on the exactness of the route marked on the maps and the scale of the maps based on which the survey was undertaken. The sampling points that were decided, during the preliminary examination, for visit and data collection were located in the field using bearings or land marks such as village, wetlands, rocky outcroppings and roads made out from the route maps. After arriving at the points the coordinates (latitude and longitude) for the locations were recorded using a Global Positioning System (GPS).

No attempt was made to check up the legal status or ownership of the land along the pipeline route during the present survey. In discussing the land use only visual observations were relied and no documentary proof were sought from the respective revenue or village administrative authorities or other governmental agencies. No attempt was made to demarcate authorized boundaries of lands under various types of ownership including that under government departments.

Flora and fauna were studied following standard methods (eg., Greig-Smith 1983, Caustan 1988). Preliminary examination indicated no major sensitive vegetation along the pipeline route. Hence, a suitable protocol for data collection was adopted that is basically based on semi-randomized cluster sampling. Taking into consideration the apparently low number of trees in the study area two quadrats of one hectare (100 X 100m) each was laid randomly in each sampling point and i) the species, ii) their number, iii) Girth at Breast Height (GBH) (Chaturvedi and Khanna 1982), and iv) total height (height of the bole from ground level + height of crown) of the trees were recorded. The total number of trees standing on the RoU were estimated as

$$N_{trees} = D^* L^* W/10$$

A where N_{trees} is the total number of trees, D is the density of trees per hectare and L is the length of the pipeline in kilometers and W, the width of the RoU in meters. As noted earlier for the purpose of the study the RoU is considered as 30m wide. Within the tree quadrats shrubs and herbs were enumerated by random walk and locating smaller quadrats. Specimens of plants whose identity could not be confirmed in the field were collected and preserved following standard methods and identified subsequently using Hooker (1961), Maheshwari (1990), Roy et al (1992), Gamble (1987), Jain and Rao (1983), Nair and Shastry (1988) and Shetty and Singh (1987). Ecologically important / sensitive areas such as National Parks, Wildlife Sanctuaries and wetlands lying in the environs of the path, which is considered here as up to a maximum 5 Km in perpendicular distance, were located on the map and surveyed laying quadrats as mentioned above.

At each sampling site animal species encountered and the signs of others present were recorded. Those that are likely to be present based on recent literature and information from the local wildlife experts were also recorded. The list of endangered species encountered was prepared based on the Wildlife Protection Act, 1972 (Anonymous 1991, Upadhyay 1995, Chaturvedi and Chaturvedi 1996) and the list provided by ZSI (1994). The type and use of land and dominant crops were also recorded at each sampling site. All the sites were graded for their ecological sensitivity based on various characteristics (Appendix 1, Usher 1986, Spellerberg 1992), such as number of endangered and endemic species present in the locality and status of the forest; whether the area is a Wildlife Sanctuary, National Park, or an already known ecologically sensitive area.

Study of the impact of the project on flora and fauna involves prediction of the potential damages on these components of the ecosystem due to the project. The prediction is done based on the baseline data on the impact zone of the project, possible disturbances that can lead to biological perturbations and damages during various phases of the project such as construction and operation. Considering the published literature, research findings and past experience a technical judgement is made on the possible damages since the damages may not be proportional to the disturbances or directly quantifiable in case of biological and ecological components. To assess the potential damages to the terrestrial and aquatic flora and fauna due to discharge of effluents and gaseous emissions from the project data on these aspects are essential. This data was provided by the Engineers India Limited (EIL). As per the information, only minor emissions due to the movement and operation of equipments is expected during the construction or operation of the project. Hence, the prediction of stress in the biological system from these emissions and proposing mitigatory measures for the same was not felt necessary. However, attempts were made to assess potential damage to terrestrial and aquatic fauna because of physical disturbances from the construction and operation of the pipeline. This was made essentially by depending on published literatures and direct experience of the many operating petroleum product pipelines in the country and elsewhere.

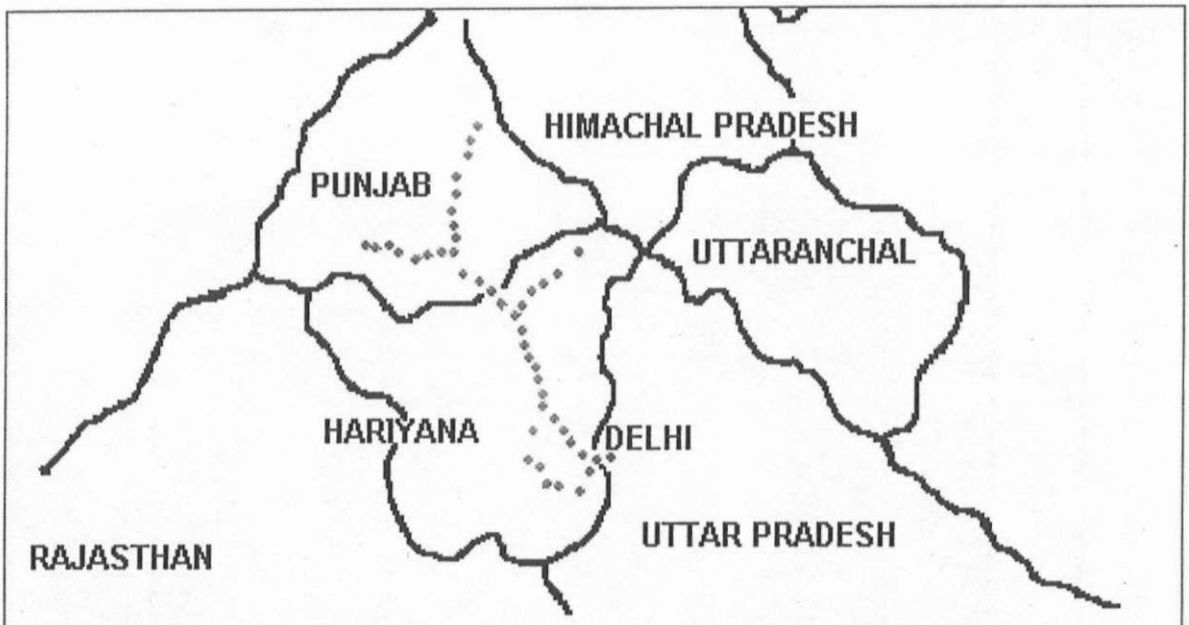

Figure 1a Sampling locations along the pipeline route (Northern sections)

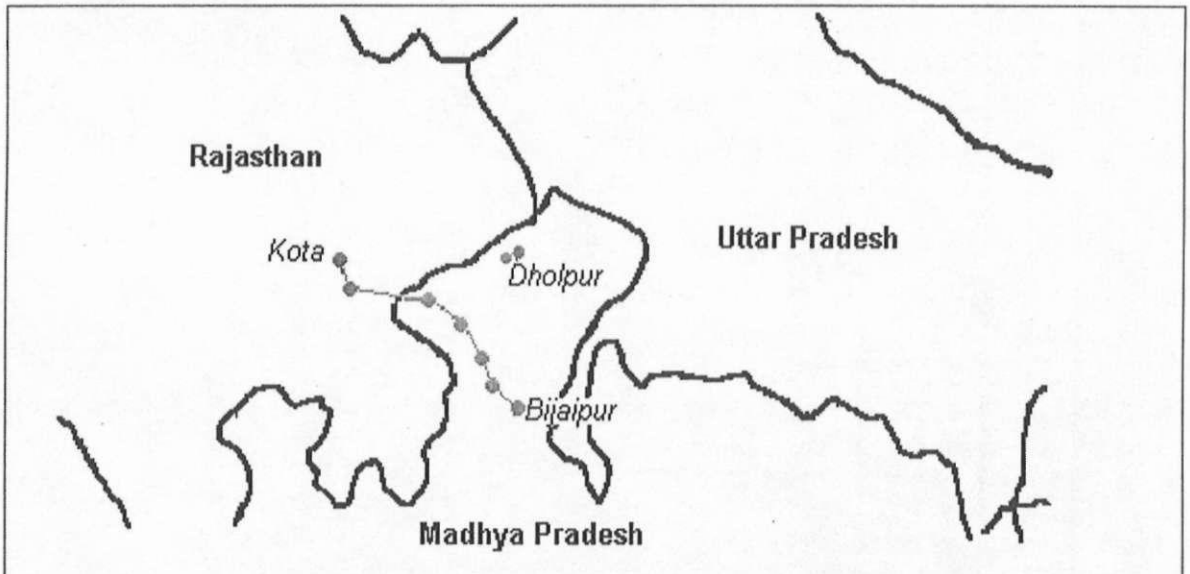

Figure 1b. Sampling locations along the pipeline route (Southern section)

4. OBSERVATIONS

The field survey was carried out during April and May (summer) 2002. Based on a preliminary inspection altogether forty-nine localities were selected, at an approximate interval of 15-20 km, along the pipeline route. These locations were to be found by means of landmarks and bearings discernable from the route map. After visiting the sites they were marked using the coordinates from a GPS and were sampled for flora and fauna (Table 1 and Figure 1a &b).

Table 1 Sampling locations along the proposed pipeline route

GPS Point No.	Latitude ^{0}	Longitude ^{0}	Nearest Village	District	State	Distance (m) *
1	28.588	77.606	NTPC Terminal	Gaziabad	UP	50
2	28.688	77.535	Dasna	Gaziabad	UP	0
3	28.752	77.495	Asalatnagar	Gaziabad	UP	0
4	28.869	77.296	Near Khekra	Meerut	UP	0
5	28.962	77.117	Kheora	Sonipat	Haryana	0
6	29.092	77.051	Laursoli	Sonipat	Haryana	0
7	29.212	76.993	Near Chilkana	Karnal	Haryana	50
8	29.394	76.911	Near Shodapur	Karnal	Haryana	0
9	29.498	76.806	Near Monak	Karnal	Haryana	0
10	29.633	76.673	Near Chor Karsa	Karnal	Haryana	0
11	29.737	76.547	Jatheri	Karnal	Haryana	0
12	29.846	76.406	Near Khurana	Kurukshetra	Haryana	0
13	29.958	76.291	Sair	Kurukshetra	Haryana	0
14	30.000	76.168	Badshapur	Patiala	Punjab	0
15	30.123	76.022	Khanal Kalan	Patiala	Punjab	0
16	30.210	75.865	Sangrur IOCL	Sangrur	Punjab	50
17	30.173	75.706	Sheron	Sangrur	Punjab	0
18	30.176	75.536	Near Kot Dunna	Sangrur	Punjab	0
19	30.176	75.252	Near Joga	Bathinda	Punjab	0
20	30.223	75.028	Bathinda Army	Bathinda	Punjab	0
21	30.253	74.913	NFL – Bathinda	Bathinda	Punjab	50
22	31.371	76.365	NFL-NayaNangal	Ropar	Punjab	50
23	31.192	76.252	Nawagram	Hoshiarpur	Punjab	0
24	31.084	76.234	Jadla	Jullundurpur	Punjab	0
25	30.802	76.026	Dorgha Mandi	Ludhiana	Punjab	200
26	30.635	75.967	Chomman	Ludhiana	Punjab	0
27	30.489	75.956	Maharand	Sangrur	Punjab	0
28	30.327	75.942	Bhalwan	Sangrur	Punjab	0
29	29.775	76.789	Sangbili	Karnal	Haryana	0
30	29.836	76.940	Nilokheri	Karnal	Haryana	0
31	29.899	77.053	Indri	Karnal	Haryana	0
32	30.010	77.240	Jatlana road	Kurukshetra	Haryana	0
33	30.096	77.327	Near Dasani	Ambala	Haryana	0
34	28.308	77.423	Korali	Ambala	Haryana	0
35	28.264	77.289	Sikri	Faridabad	Haryana	0
36	28.259	77.141	Harsandpur	Gurgaon	Haryana	0
37	28.417	77.047	Badshapur	Gurgaon	Haryana	0
38	28.472	76.954	Near Dhankot	Gurgaon	Haryana	0
39	28.676	76.937	Bagadurgarh	Rohtak	Haryana	100

GPS Point No.	Latitude ^{0}	Longitude ^{0}	Nearest Village	District	State	Distance (m) *
40	25.324	75.941	Keshorajpatan	Bundi	Rajasthan	250
41	25.182	75.918	Samcore	Kota	Rajasthan	50
42	25.146	76.191	Chambal FC	Kota	Rajasthan	200
43	25.167	76.325	Tamkheda	Kota	Rajasthan	0
44	25.054	76.534	Mandola SV	Kota	Rajasthan	50
45	24.906	76.636	Near Atru	Kota	Rajasthan	50
46	24.866	76.662	Atru	Kota	Rajasthan	50
47	24.673	76.853	Chhabra	Guna	MP	100
48	28.699	77.829	RPG Dhoulpur	Bharatpur	Rajasthan	0
49	26.698	77.560	Ibrahimpur	Dhaulpur	Rajasthan	0

Note :1) At each sampling location the protocol adopted to collect primary data were for trees – two quadrats of 100 x 100m, shrubs – 4 quadrats of 5 x 5m and herbs – 10 quadrats of 1 x 1m.2) All the sampling plots are on or within the 500m of the pipeline route

4.1. LAND USE ALONG THE ROUTE

The pipeline mostly passes through agricultural fields, plantations and wastelands (Appendix 2; Plate 1). Major crop species cultivated along the route and its environs are wheat (*Triticum aestivum*), paddy (*Oryza sativa*), sugar cane (*Saccharum officinarum*), bringal (*Solanum melongena*), ladies finger (*Abelmoschus esculentus*), mustard (*Brassica nigra*), green chilly (*Capsicum annum*), jowar (*Sorghum bicolor*) and guava (*Psidium guava*; Table 2). The pipeline on its course crosses a number of rivers, wetlands and forests (Table 3, 4; Plate 2). The major rivers crossing the pipeline route are Yamuna, Hindon, Sutlej, Soan, Chambal and Ghaggar (Table 3).

Table 2. Important cultivated plants seen in the environs of the pipeline route

Scientific name	English name
Triticum aestivum	Wheat
Oryza sativa	Paddy
Zea mays	Maize
Sorghum bicolor	Jowar
Saccharum officinarum	Sugar cane
Solanum melongena	Brinjal
Lycopersicon esculentum	Tomato
Abelmoschus esculentus	Ladies finger
Capsicum annuum	Green chilly
Brassica oleracea var. capitata	Cabbage
Brassica nigra	Mustard
Trigonella foenum-graecum	Fenugreek
Psidium guava	Guava
Punica granatum	Pomegranate
Carica papaya	Papaya

Table 3. Major wetlands/ Rivers along the pipeline route

Pipeline sections	River Crossing	Wetland	Nearest Village
Dadri – Sonipat	Hindon	-	Bihang
	Yamuna	-	Katha
Panipat – Sangrur		Western Yamuna canal crossing; Bhakhara canal crossing	Panipat
	Ghaggar	-	Kasaur
	Chao	-	-
Sangrur – Ludhiana		Sirhind main canal crossing	-
Ludhiana – Nangal	Sutlej	-	Sansowal
	Soan	-	Suksal
Vijaipur – Kota Vijaipur - Gadepan Gadepan – Kota	Chambal	-	Keshoraj Patan
Chor Karsa – Yamunanagar	-	Western Yamuna canal crossing	Several places
Iprahimpur – Dhoulpur	Mendki	-	Gopalpur

Table 4. Major forest areas in the vicinity of the pipeline route

No.	Pipeline sections	Forest name & legal status	Nearest Village	District & State
1	Vijaipur – Kota Gadepan - Kota	Jalwara protected forest	Atru	Kota, Rajasthan
2	Panipat - Sangrur	Siwan RF	Khurana	Kurukshetra, Haryana
3	Ludhiana – Nangal	Katardhar protected forest	Nawagram	Hoshiarpur, Punjab

4.2. STATUS OF FOREST

No Sanctuary or National Parks exist along the pipeline route. However, a few thick vegetation areas, but mostly highly disturbed, was seen along certain parts. Katardhar protected forest is a hill forest (Plate 2a) seen in the Ludhiana – Nangal section. The forest types expected along the tract are tropical dry deciduous and tropical thorn forests (Champion and Seth 1968).

4.3. FLORA

One hundred and five species of plants comprising two species of climbers, 46 herbs, 23 shrubs, one parasite and 33 trees were recorded along the pipeline route and its environment (Appendix 3). The highest number of floral species (44) was seen in Panipat-Sangrur and Chor Karsa-Yamunanagar sections (Sector 3 & 7) followed by Dadri-Sonipat and Ludhiana-Nangal

(Sector 1& 5) sections. The sector 2 (Sonipat-Panipat) has the lowest number (11) of species (Table 5).

4.3.1. Aquatic plants

As noted earlier, wetlands such as village tanks, pools, rivers and nearby ponds occur along the pipeline route and its vicinity. *Ammannia baccifera, Eichornia crassipes, Hydrilla verticillata, Ipomoea cornea, Nelumbo nucifera, Nymphaea stellata, Paspalidium geminatum, Typha angustata* and *Valisneria* spp are frequent in these wetlands and rivers. In rivers most of the species are found towards the banks and inundations where the water more or less remains stagnant or swamp only seasonally.

Table 5. Plant species richness in various pipeline sections

No.	Sector	Plant category					Total
		Climbers	Herbs	Shrubs	Parasite	Trees	
1	Dadri – Sonipat		16	7		7	30
2	Sonipat – Panipat		6	2		3	11
3	Panipat – Sangrur	1	20	7	1	15	44
4	Sangrur – Ludhiana		8	2		11	21
5	Ludhiana – Nangal	1	10	8		11	30
6	Sangrur – Bathinda		12	6		9	27
7	Chor Karsa– Yamunanagar	2	17	10		15	44
8	Faridabad – Bahadurgargh		13	5		11	29
	Faridabad –Gurugaon		10	4		11	25
	Gurugaon-Bahadurgargh		8	4		4	16
9	Vijaipur – Kota		7	8		8	23
	Vijaipur – Gadepan		7	8		8	23
	Gadepan – Kota		7	8		8	23
10	Ibrahimpur – Dhoulpur		7	6		4	17
Overall		2	46	23	1	33	105

4.3.2. Floristic composition of various pipeline sections

4.3.2.1. Dadri - Sonipat (Sector 1)

Most of the areas in this sector are under agriculture. The major tree species found in this sector are *Acacia nilotica, Azadirachta indica, Capparis decidua, Dalbergia sissoo, Eucalyptus* sp, *Phoenix sylvestris* and *Prosopis juliflora*. Common shrubs in sector 1 are *Abutilon hirtum, Agave americana, Calotropis gigantea, Kirganelia reticulata, Ricinus communis* and *Saccharum spontaneum*. Common herbs are *Achyranthes aspera, Amaranthus spinosus,*

A. viridis, Cannabis sativa, Cassia occidentalis, Chenopodium ambrosoides, Chloris barbata, Croton sparciflorus, Cynodon dactylon, Gompherena celosioides, Parthenium hysterophorus and *Triumfettta annua*. Plants such as *Eichhornia crassipes, Hydrilla verticillata, Spirodela* sp. and *Ammania* sp. are common in wetlands of this section.

NTPC Terminal

Tree species such as *Phoenix* sylvestris and *Ricinus communis* are common near the NTPC terminal, Dadri. Common undergrowths *included Achyranthes aspera, Amaranthus spinosus, Ammania sp, Chenopodium ambrosoides, Chloris barbata, Croton sparciflorus, Gompherena decumbens* and *Parthenium hysterophorus*. Aquatic plants such as *Eichhornia crassipes* and *Hydrilla verticillata* are common in waterlogged areas.

Dasna

At Dasna, common plants are *Phoenix sylvestris, Abutilon hirtum, Saccharum spontaneum, Triumfetta annua* and *Cannabis sativa.*

Asalatnagar

Plant species such as *Dalbergia sissoo, Eucalyptus* sp, *Calotropis gigantea, Kirganelia reticulata, Saccharum spontaneum, Zea mays, Achyranthes aspera, Amaranthus viridis, Cassia occidentalis, Cynodon dactylon* and *Parthenium hysterophorus* are common in Asalatnagar.

Near Khekra

Common plants near Khekra included, *Dalbergia sissoo, Calotropis gigantea, Agave americana, Parthenium hysterophorus* and *Cassia occidentalis.*

Kheora

In Kheora, plants such as *Acacia nilotica, Azadirachta indica, Capparis decidua, Prosopis juliflora, Calotropis gigantea, Saccharum spontaneum* and *Achyranthes aspera* are common.

4.3.2.2. Sonipat - Panipat (Sector 2)

Thickets of *Prosopis juliflora* are common in this sector. A major portion of this sector is under agriculture. The common tree species in this sector are *Acacia nilotica, Phoenix sylvestris* and *Prosopis juliflora*. Common shrubs and herbs in this section included *Alhagi maurorum, Amaranthus viridis, Ammania* sp, *Chrozophora rottleri, Cynodon dactylon, Parthenium hysterophorus* and *Calotropis gigantea*.

Laursoli

Thickets of *Prosopis juliflora* are common at Laursoli. The common undergrowth included *Calotropis gigantea* and *Parthenium hysterophorus*.

Near Chilkana

Common tree species near Chilkana included *Acacia nilotica, Phoenix sylvestris* and *Prosopis juliflora*. Thickets of *Prosopis juliflora* are common in this area. Common shrubs are *Calotropis gigantea* and *Abutilon hirtum*. Herbs and grass species such as *Ammania* sp, *Amaranthus viridis, Parthenium hysterophorus, Cynodon dactylon, Chrozophora rottleri* and *Alhagi maurorum* are common near Chilkana.

4.3.2.3. Panipat - Sangrur (Sector 3)

Most of the area in this sector is under agriculture. Common crops cultivated in this sector included wheat (*Triticum aestivum*), brinjal (*Solanum melongena*) and tomato (*Lysopersicon esculentum*). The trees found in sector 3 are *Acacia nilotica, Ailanthus excelsa, Azadirachta indica, Balanites aegyptiaca, Broussonetia papyrifera, Capparis decidua, Dalbergia sissoo, Eucalyptus* sp, *Melia azadirach, Prosopis juliflora, Salvadora oleoides, Syzygium cumini, Terminalia* sp and *Zizyphus mauritiana*. Poplar (*Populus ciliata*), a tree used for making plywood is extensively planted in this section. The common shrubs found here are *Abutilon hirtum, Calotropis gigantea, Capparis sepiaria, Grewia* sp, *Kirganelia reticulata, Saccharum spontaneum* and *Xanthium strumarium*. Herbs and climbers such as *Achyranthes aspera,*

Alhagi maurorum, Argemone mexicana, Boerhavia diffusa, Brassica nigra, Cannabis sativa, Cassia occidentalis, Celosia argentea, Chenopodium murale, Chloris barbata, Cocculus hirsutus, Coronopus didymus, Croton sparciflorus, Cynodon dactylon, Eichhornia crassipes, Gompherena celosioides, Malvastrum coromandelianum, Oxalis corniculata, Parthenium hysterophorus, Sonchus oleraceus and Triumfetta annua are also common in the sector. *Cuscuta reflexa*, a parasitic plant is also common in this sector.

Near Shodapur

Thickets of *Prosopis juliflora* and *Capparis sepiaria* are common in this area. Other common trees are *Acacia nilotica* and *Eucalyptus* sp. *Achyranthes aspera, Parthenium hysterophorus, Cynodon dactylon* and *Gompherena decumbens* are common herbs.

Near Monak

Trees such as *Ailanthus excelsa* and *Acacia nilotica* are common near Monak. Common undergrowths are *Calotropis gigantea, Abutilon hirtum, Saccharum spontaneum, Cynodon dactylon, Achyranthes aspera, Brassica nigra, Parthenium hysterophorus, Chenopodium murale, Alhagi maurorum* and *Boerhavia diffusa.*

Near Chor Karsa

Common plants near Chor Karsa are *Acacia nilotica, Zizyphus mauritiana, Calotropis gigantea, Kirganelia reticulata, Achyranthes aspera, Malvastrum coromandelianum, Parthenium hysterophorus, Cynodon dactylon, Alhagi maurorum, Sonchus oleraceus* and *Eichhornia crassipes.*

Jatheri

In Jatheri, plants such as *Dalbergia sissoo, Acacia nilotica and Broussonetea payerifolia* are common. Common undergrowths are *Capparis sepiaria, Kirganelia reticulata, Achyranthes aspera, Cynodon dactylon, Parthenium hysterophorus, Cassia occidentalis* and *Triumfetta annua.*

Near Khurana

Near Khurana, common trees are *Eucalyptus* sp, *Prosopis juliflora*, *Acacia nilotica*, *Salvadora oleoides*, *Azadirachta indica.* Common shrubs included *Calotropis gigantea* and *Abutilon hirtum*. Common herbs are *Cynodon dactylon, Parthenium hysterophorus, Achyranthes aspera and Croton sparciflorus*.

Sair

At Sair, plant species such as *Acacia nilotica, Syzygium cumini, Melia azadirach, Calotropis gigantea* and *Parthenium hysterophorus* are common.

Badshapur

Acacia nilotica, is the common tree in Badshapur. Common undergrowths are *Chloris barbata, Cynodon dactylon, Parthenium hysterophorus, Coronopus didymus, Achyranthes aspera, Celosia argentea* and *Brassica nigra*.

Khanal Kalan

At Khanal Kalan, *Populus ciliata, Eucalyptus* sp, *Calotropis gigantea, Cynodon dactylon, Achyranthes aspera, Cannabis sativa, Parthenium hysterophorus, Malvastrum coromandelianum, Celosia argentea, Chenopodium murale* and *Oxalis corniculata* are common plants.

Sangrur IOCL

Common trees in Sangrur included *Acacia nilotica, Azadirachta indica, Balanites aegyptaca, Capparis decidua, Populus ciliata, Terminalia* sp *and Zizyphus mauritiana*. Shrubs such as *Xanthium strumarium, Calotropis gigantea, Grewia* sp and *Capparis sepiaria* are common in Sangrur. Common herbs included *Achyranthes aspera, Chenopodium murale, Cynodon dactylon, Parthenium hysterophorus, Sonchus oleraceus* and *Cuscuta reflexa*.

4.3.2.4. Sangrur- Ludhiana (Sector 4)

Most of the area in this sector is under agriculture. Trees such as *Acacia nilotica, Azadirachta indica, Cassia siamea, Dalbergia sissoo, Eucalyptus* sp,

Mangifera indica, Melia azadirach, Populus ciliata, Prosopis juliflora, Terminalia sp and *Zizyphus mauritiana* are common in this sector. Common undergrowths in this sector included *Abutilon hirtum, Calotropis gigantea, Achyranthes aspera, Boerhavia erecta, Cannabis sativa, Chloris barbata, Cynodon dactylon, Echinops echinatus, Malvastrum coromandelianum* and *Parthenium hysterophorus.*

Chomman

In Chomman, common trees are *Dalbergia sissoo* and *Mangifera indica.* Common herbs are *Achyranthes aspera, Cannabis sativa, Parthenium hysterophorus, Cynodon dactylon, Echinops echinatus* and *Malvastrum coromandelianum.*

Maharand

Tree species such *as Eucalyptus* sp, *Melia azadirach, Dalbergia sissoo, Cassia siamea* and *Terminalia* sp are common in Maharand. Common shrubs and herbs included *Calotropis gigantea, Cynodon dactylon, Achyranthes aspera, Cannabis sativa* and *Parthenium hysterophorus.*

Bhalwan

Common tree species are *Acacia nilotica, Populus ciliata* and *Zizyphus mauritiana.* Common shrubs are *Calotropis gigantea* and *Abutilon hirtum.* Common herbs included *Cannabis sativa, Parthenium hysterophorus, Achyranthes aspera, Malvastrum coromandelianum* and *Cynodon dactylon.*

4.3.2.5. Ludhiana - Nangal (Sector 5)

Common crops cultivated in this sector included onion (*Allium cepa*), tomato (*Lycopersicon esculentum*) and brinjal (*Solanum melongena*). Common trees in this sector included *Ailanthus excelsa, Albizzia lebbeck, Azadirachta indica, Kigelia pinnata,. Cassia siamea, Dalbergia sissoo, Eucalyptus* sp, *Melia azadirach, Phoenix sylvestris, Populus ciliata* and *Zizyphus mauritiana. Calotropis gigantea, Ipomoea carnea, Murraya koenigi, Phragmites kurka* and

Saccharum spontaneum are common shrubs in this sector. Common herbs and climbers in this sector included *Amaranthus viridis, Boerhavia diffusa, Cannabis sativa, Cassia occidentalis, Cocculus hirsutus, Chloris barbata, Cynodon dactylon, Digitaria bicornis* and *Malvastrum coromandelianum.* Exotic weeds such as *Lantana camara* and *Parthenium hysterophorus* are also common in this sector.

NFL- Naya Nangal

Eucalyptus sp and *Kigelia pinnata* are common trees in Naya Nangal. Common undergrowths are *Saccharum spontaneum, Lantana camara, Cynodon dactylon, Parthenium hysterophorus* and *Boerhavia diffusa.*

Nawagram

In Nawagram, *Dalbergia sissoo, Melia azdirach, Albizzia lebbeck, Azadirchta indica, Murraya koenigi, Ricinus communis, Phragmites kurka, Lantana camara, Cannabis sativa* and *Cocculus hirsutus* are common plants.

Jadla

Common trees at Jadla *are Dalbergia sissoo, Phoenix sylvestris, Populus ciliata* and *Ailanthus excelsa.* Common herbs and climbers included *Amaranthus viridis, Parthenium hysterophorus, Chloris barbata, Cannabis sativa, Cassia occidentalis, Digitaria bicornis* and *Cocculus hirsutus.*

Dorgha Mandi

Common trees at Dorgha Mandi are *Eucalyptus* sp, *Cassia siamea and Zizyphus mauritiana.* Common shrubs and herbs *are Calotropis gigantea, Cannabis sativa* and *Cynodon dactylon.*

4.3.2.6. Sangrur - Bathinda (Sector 6)

Trees found in this sector are *Acacia nilotica, Acacia* sp, *Azadirachta indica, Eucalyptus* sp, *Parkinsonia aculeatea, Prosopis cineraria, P. juliflora, Terminalia* sp and *Zizyphus mauritiana.* Common shrubs in this sector 4

included *Abutilon hirtum, Calotropis gigantea, Capparis sepiaria, Datura metel, Nerium oleander* and *Saccharum spontaneum*. Herbs such as *Achyranthes aspera, Ammania* sp, *Cannabis sativa, Chenopodium murale, Croton sparciflorus, Cynodon dactylon, Eragrostis* sp, *Panicum* sp, *Parthenium hysterophorus, Sonchus oleraceus, Tragus* sp and *Triumfetta rotundifolia* are common in this sector.

Sheron

At Sheron, Acacia sp, *Prosopis juliflora* and *Zizyphus mauritiana* are common trees. Common undergrowths are *Calotropis gigantea, Croton sparciflorus, Cannabis sativa, Cynodon dactylon* and *Achyranthes aspera*.

Near Kot Dunna

Common trees near Kot Dunna are *Acacia nilotica, Eucalyptus* sp and *Terminalia* sp. Common undergrowths are *Calotropis gigantea, Saccharum spontaneum, Nerium oleander, Sonchus oleraceus, Ammania* sp and *Cynodon dactylon*.

Near Joga

Common plants in this area included *Acacia nilotica, Acacia* sp, *Calotropis gigantea, Capparis sepiaria, Achyranthes aspera, Cynodon dactylon* and *Ammania* sp.

Near Bathinda - Army camp

Common plants in this area are *Acacia nilotica, Azadirachta indica, Parkinsonia aculeatea, Prosopis cineraria* and *P. juliflora*.

NFL – Bathinda

Thickets of *Prosopis juliflora* are common in Bathinda. Plantation of Eucalyptus is also common in Bathinda. Common shrubs *are Abutilon hirtum, Calotropis gigantea, Datura metel* and *Saccharum spontaneum*. Common herbs are *Achyranthes aspera, Cannabis sativa, Croton sparciflorus,*

Eragrostis sp, Panicum sp, Parthenium hysterophorus, Tragus sp and *Triumfetta rotundifolia.*

4.3.2.7. Chor Karsa - Yamunanagar (Sector 7)

Most of the areas in this sector are under agriculture and wastelands. A total of 44 plant species are recorded in this section. Common crops cultivated in this sector included wheat (*Triticum aestivum*), Cabbage (*Brassica oleracea* var. *capitata*) and sugarcane (*Saccharum officinarum*). Common trees in Chor Karsa - Yamunanagar pipeline section included *Acacia nilotica, Ailanthus excelsa, Azadirachta indica, Bombax ceiba, Butea monosperma, Cassia siamea, Dalbergia sissoo, Enterolobium saman, Eucalyptus* sp, *Mangifera indica, Phoenix sylvestris, Pongamia pinnata, Populus ciliata, Prosopis juliflora* and *Syzygium cumini.* Shrubs such as *Abutilon hirtum, Bogainvillea glabra, Capparis sepiaria, Justicia betonica, Kirganelia reticulata, Lantana camara, Nerium oleander* and *Saccharum spontaneum.* Common herbs in this sector included *Achyranthes aspera, Amaranthus viridis, Boerhavia diffusa, Cannabis sativa, Cassia occidentalis, Chenopodium murale, Cocculus hirsutus, Cucumis* sp, *Croton sparciflorus, Cynodon dactylon, Eichhornia crassipes, Malvastrum coromandelianum, Parthenium hysterophorus, Sida cordata, Solanum indicum, Triumfetta rotundifolia* and *Vernonia cinerea.*

Sangbili

Thickets of *Prosopis juliflora* are common in Sangbili. Common herbs are *Achyranthes aspera, Chenopodium murale, Cynodon dactylon, Eichhornia crassipes* and *Parthenium hysterophorus.*

Nilokheri

In Nilokheri, *Eucalyptus* sp, *Ailanthus excelsa, Cassia siamea and Pongamia pinnata* are common trees. Common shrubs are *Bogainvillea glabra, Nerium oleander* and *Abutilon hirtum.* Common herbs in Nilokheri *are Parthenium hysterophorus, Cynodon dactylon* and *Chenopodium murale.*

Indri

Common trees are *Azadirachta indica, Bombax ceiba, Butea monosperma, Dalbergia sissoo, Enterolobium saman, Eucalyptus sp, Phoenix sylvestris* and *Prosopis juliflora*. Common shrubs at Indri included *Kirganelia reticulata* and *Justicia betonica*. *Achyranthes aspera, Parthenium hysterophorus, Amaranthus viridis, Cynodon dactylon, Triumfetta rotundifolia* and *Boerhavia diffusa* are common herbs.

Jatlana road

Tree species such as *Acacia nilotica, Eucalyptus* sp, *Mangifera indica* and *Populus ciliata* are common in this area. Common shrubs are *Kirganelia reticulata, Lantana camara* and *Saccharum officinarum. Achyranthes aspera, Malvastrum coromandelianum, Triumfetta rotundifolia, Parthenium hysterophorus, Solanum indicum* and *Cocculus hirsutus* are common herbs and climbers.

Near Dasani

Near Dasani, common trees are *Dalbergia sissoo, Eucalyptus* sp, *Populus ciliata* and *Syzygium cumini*. Common undergrowths are *Kirganelia reticulata, Achyranthes aspera, Parthenium hysterophorus, Vernonia cinerea, Cannabis sativa, Sida cordata, Croton sparciflorus, Cassia occidentalis and Malvastrum coromandelianum.*

4.3.2.8. Faridabad - Bahadurgargh (Sector 8)

Common trees in sector 8 included *Acacia leucopholea, Acacia nilotica, Ailanthus excelsa, Azadirachta indica, Bambusa arundinacea, Callistemon citrinus, Cassia siamea, Dalbergia sissoo, Grevillea robusta, Melia azadirach* and *Prosopis juliflora*. Common shrubs and stragglers included *Bogainvillea glabra, Calotropis gigantea, Saccharum spontaneum, Xanthium strumarium* and *Zizyphus nummularia*. Herbs such as *Achyranthes aspera, Alhagi maurorum, Argemone mexicana, Boerhavia diffusa, Cannabis sativa, Chenopodium murale, Chloris barbata, Croton sparciflorus, Cynodon*

dactylon, Echinops echinatus, Parthenium hysterophorus, Sonchus oleraceus and *Withania somnifera* are common in this sector.

Korali

At Korali, *Acacia nilotica, Azadirachta indica* and *Melia azadirach* are common trees. Common herbs are *Cynodon dactylon, Parthenium hysterophorus, Achyranthes aspera, Boerhavia diffusa* and *Sonchus oleraceus.*

Sikri

Cassia siamea, Dalbergia sissoo, Cassia siamea, Azadirachta indica, Prosopis juliflora and *Callistemon citrinus* are common trees in Sikri. *Bogainvillea glabra, Alhagi maurorum, Cannabis sativa, Chenopodium murale, Cynodon dactylon, Echinops echinatus* and *Parthenium hysterophorus* are common shrubs and herbs.

Harsandpur

Acacia nilotica, Grevillea robusta, Ailanthus excelsa, Bambusa arundinacea and *Cassia siamea* are common trees. Plants such *as Calotropis gigantea, Achyranthes aspera* and *Parthenium hysterophorus* are also common in Harsandpur.

Badshapur

At Badshapur, *Acacia leucopholea, A. nilotica, Ailanthus excelsa, Cassia siamea, Dalbergia sissoo* and *Prosopis juliflora* are common trees. *Calotropis gigantea, Parthenium hysterophorus, Cynodon dactylon* and *Croton sparciflorus* are common shrubs and herbs.

Near Dhankot (Gurugaon - Bahadurgargh)

Tree species such as *Acacia nilotica, Ailanthus excelsa* and *Dalbergia sissoo* are common near Dhankot. Common herbs included *Parthenium hysterophorus, Achyranthes aspera, Chloris barbata, Cynodon dactylon Sonchus oleraceus* and *Withania somnifera.*

Bagadurgarh (Gurugaon - Bahadurgargh)

Common trees at Bagadurgarh are *Dalbergia sissoo*, *Azadirachta indica* and *Acacia nilotica*. *Calotropis gigantea, Xanthium strumarium, Cynodon dactylon, Argemone mexicana, Parthenium hysterophorus* and *Alhagi maurorum* are common shrubs and herbs.

4.3.2.9. Vijaipur - Kota (Sector 9)

Most of the areas in this sector are under agriculture. The trees found in this sector 9 are *Acacia nilotica, Ailanthus excelsa, Capparis decidua, Dalbergia sissoo, Eucalyptus* sp, *Feronia elephantum, Prosopis juliflora* and *Syzygium cumini*. Common shrubs and stragglers included *Abutilon hirtum, Calotropis gigantea, Ipomoea carnea, Kirganelia reticulata, Lantana camara, Nerium oleander, Xanthium strumarium* and *Zizyphus nummularia*. Common herbs in this sector included *Cynodon dactylon, Echinops echinatus, Euphorbia hirta, Ocimum* sp, *Parthenium hysterophorus, Sida cordata* and *Triumfetta annua*. The floristic composition of the spur lines such as Kawai – Peeraj power plant, Boreri – NTPC Anta, Samcore – Keshoraj Patan and Samcore – Bhagat conform with the general floristic composition of the sector.

Keshorajpatan

At Keshorajpatan, thickets of *Prosopis juliflora* are common. Common trees and shrubs included, *Ailanthus excelsa, Dalbergia sissoo, Eucalyptus* sp and *Ipomoea carnea*.

Samcore

Dalbergia sissoo, Eucalyptus sp and *Acacia nilotica* are common trees near Samcore. *Lantana camara, Calotropis gigantea* and *Parthenium hysterophorus* are other common plants in Samcore.

Chambal FC

Thickets of *Prosopis juliflora* are common near the Chambal Fertiliser complex. *Acacia nilotica* is the other common tree in this area. Common

undergrowths are *Xanthium strumarium, Achyranthes aspera* and *Echinops echinatus.*

Tamkheda

Common trees at Tamkheda included *Acacia nilotica, Eucalyptus* sp, *Dalbergia sissoo* and *Capparis decidua.* Common shrubs *are Calotropis gigantea, Abutilon hirtum* and *Xanthium strumarium.*

Mandola SV Station

At Mandola, *Syzygium cumini, Acacia nilotica, Prosopis juliflora* and *Eucalyptus* sp are common trees. Common undergrowths in Mandola are *Ipomoea carnea, Calotropis gigantea, Cynodon dactylon, Kirganelia reticulata* and *Nerium oleander.*

Near Atru

Common plants near Atru are *Acacia nilotica, Feronia elephantum, Calotropis gigantea* and *Cynodon dactylon.*

Atru

Acacia nilotica is the common tree at Atru. *Ipomoea carnea* and *Kirganelia reticulata* are common shrubs in Atru.

Chhabra

Thickets of *Prosopis juliflora* are common at Chhabra. Common undergrowths are *Calotropis gigantea, Achyranthes aspera* and *Echinops echinatus.*

4.3.2.10. Ibrahimpur - Dhoulpur (Sector 10)

Common tree species in this sector included *Acacia nilotica, Carica papaya, Pongamia pinnata* and *Prosopis juliflora.* Common shrubs in sector 10 included *Calotropis gigantea, Lantana camara, Lawsonia inermis, Saccharum spontaneum, Xanthium strumarium* and *Zizyphus nummularia.* Herbs such as

Achyranthes aspera, Cynodon dactylon, Echinops echinatus, Euphorbia hirta, E. rosea, Heliotropium sp and *Vinca rosea* are common in this sector.

Dhoulpur

Common plants at Dhoulpur are *Acacia nilotica, Prosopis juliflora, Calotropis gigantea, Saccharum spontaneum, Lantana camara, Zizyphus nummularia, Cynodon dactylon, Achyranthes aspera* and *Echinops echinatus.*

Ibrahimpur

Common trees at Ibrahimpur included *Pongamia pinnata* and *Carica papaya.* Common shrubs are *Calotropis gigantea, Zizyphus nummularia, Saccharum spontaneum, Xanthium strumarium* and *Lawsonia inermis.* Herbs such as *Heliotropium* sp, *Euphorbia hirta, Euphorbia rosea* and *Vinca rosea* are common in Ibrahimpur.

The floral composition of the intermediate compressor station such as Vijaipur and Dadri conform with the general floristic composition of the concerned pipeline sections (Appendix 3). No indigenous species of plants were found restricted to the sites of these compressor stations.

4.4. MAJOR TREES ALONG THE RoU

The major tree species along the pipeline route are *Acacia leucopholea, A. nilotica, Ailanthus excelsa, Albizzia lebbeck, Azadirachta indica, Balanites aegyptaca, Bombax ceiba, Butea monosperma, Callistemon citrinus, Capparis decidua, Carica papaya, Cassia siamea, Dalbergia sissoo, Enterolobium saman, Eucalyptus* sp, *Feronia elephantum, Grevillea robusta, Mangifera indica, Melia azadirach, Parkinsonia aculeatea, Phoenix sylvestris, Pongamia pinnata, Populus ciliata, Prosopis cineraria, P. juliflora, Salvadora oleoides, Syzygium cumini, Terminalia* sp and *Zizyphus mauritiana.* Trees such as Babul (*Acacia nilotica*), Shisham (*Dalbergia sissoo*), Poplar (*Populus ciliata*) and (*Prosopis juliflora*) constitute about 48% of the total trees. Poplar is

extensively planted in Panipat - Sangrur and Chor Karsa - Yamunanagar pipeline sections. This tree constitutes about 29% and 22% of the total trees in Panipat - Sangrur and Chor Karsa - Yamunanagar pipeline sections respectively.

GBH of trees varied between 20cm and 140cm, the average being 61.5cm. Average height of the trees was 8.5m, the range being between 1 and 21m. GBH and height class distributions of trees (above 20cm GBH) in various pipeline sections are given in Table 6 and Table 7 respectively. Considering the width of the RoU as 30m, the total area necessary for the pipeline is about 2262 ha. The total number of trees, occurring along the RoU that will be felled in various pipeline sections for the project calculated based on the sample survey is 74,083 (Appendix 4).

Table 6. GBH class distribution of trees in various pipeline sections

GBH class (Cm)	Sector											
	1	2	3	4	5	6	7	8a	8b	9a	9b	10
	%	%	%	%	%	%	%	%	%	%	%	%
25- 50	42	0	50	41	21	33	26	59	78	0	53	80
51-75	25	33	21	43	60	22	35	28	11	0	17	20
76-100	25	50	21	14	17	39	32	10	0	0	22	0
101-125	8	17	4	2	2	6	6	3	0	0	8	0
126-150	0	0	3	0	0	0	0	0	11	0	0	0
Total	100	100	100	100	100	100	100	100	100	0	100	100

Pipeline Sectors: 1. Dadri - Sonipat; 2. Sonipat - Panipat; 3. Panipat – Sangrur; 4. Sangrur - Ludhiana; 5. Ludhiana - Nangal; 6. Sangrur - Bathinda; 7. Chor Karsa - Yamunanagar; 8a Faridabad – Gurgaon; 8b Gurgaon – Bahadurgargh; 9a Vijaipur – Gadepan; 9b. Gadepan - Kota; 10. Ibrahimpur - Dhoulpur:

Table 7. Height class distribution of trees in various pipeline sections

Height class (m)	Sector												
	1	2	3	4	5	6	7	8	8a	8b	9a	9b	10
	%	%	%	%	%	%	%	%	%	%	%	%	%
<5	42	17	36	22	4	39	7	63	55	90	0	53	80
6 – 10	42	83	34	36	43	56	15	34	45	0	0	25	20
11-15	17	0	30	41	53	6	77	3	0	10	0	22	0
16-20	0	0	0	0	0	0	0	0	0	0	0	0	0
21-25	0	0	0	0	0	0	1	0	0	0	0	0	0
Total	100	100	100	100	100	100	100	100	100	100	0	100	100

Pipeline Sectors: 1. Dadri - Sonipat; 2. Sonipat - Panipat; 3. Panipat – Sangrur; 4. Sangrur - Ludhiana; 5. Ludhiana - Nangal; 6. Sangrur - Bathinda; 7. Chor Karsa – Yamunanagar; 8. Faridabad - Bahadurgargh; 8a Faridabad – Gurgaon; 8b Gurgaon – Bahadurgargh; 9a. Vijaipur – Gadepan; 9b Gadepan- Kota; 10. Ibrahimpur - Dhoulpur:

4.5. FAUNA

4.5.1. Butterflies

A total of 30 species of butterflies were observed during the present study. The areas through which the pipeline passes are mostly open areas dominated by agriculture lands. Hence, the butterfly community was dominated by common generalist species that are distributed widely (Table 8).

Table 8. Butterflies observed along the pipeline route and its environs

No.	Common name	Scientific name	Family
1	Blue Tiger	*Tirumala limniace leopardus* Butler	Danaidae
2	Common Crow	*Euploea core core* Cramer	Danaidae
3	Plain Tiger	*Danaus chrysippus* Lin.	Danaidae
4	Striped Tiger	*Danaus genutia* Cramer	Danaidae
5	Angled Pierrot	*Caleta caleta decidea* Hewitson	Lycaenidae
6	Common Pierrot	*Castalius rosimon* (Fabricius)	Lycaenidae
7	Common Cerulean	*Jamides celeno celeno* Cramer	Lycaenidae
8	Dark Cerulean	*Jamides bochus* Cramer	Lycaenidae
9	Pale Grass Blue	*Pseudozizeeria maha* (Kiollar)	Lycaenidae
10	Slate Flash	*Rapala scintilla*	Lycaenidae
11	Angled Castor	*Ariadne ariadne palliolior* Fruhstorfer	Nymphalidae
12	Blue Pansy	*Precis orithya ocyale* Hubener	Nymphalidae
13	Chocolate Pansy	*Precis iphita* Cramer	Nymphalidae
14	Common Sailor	*Neptis hylas varmona* Moore	Nymphalidae
15	Grey Pansy	*Precis atlites atlites* (Johanssen)	Nymphalidae
16	Lemon Pansy	*Precis lemonias lemonias* Lin.	Nymphalidae
17	Tawny Coster	*Acraea violae* Horsfield	Nymphalidae
18	Yellow Pansy	*Precis hierta magna* Evans	Nymphalidae
19	Common Mormon	*Princeps polytes romulus* Cramer	Papilionidae
20	Common Rose	*Pachliopta aristolochiae aristolochiae*	Papilionidae
21	Lime Butterfly	*Princeps demoleus* Lin.	Papilionidae
22	Common Wanderer	*Pareronia valeria hippia* Fabricius	Pieridae
23	Common Emigrant	*Catopsilia pomona* Fabricius	Pieridae
24	Common Grass Yellow	*Eurema hecabe contubernalis* Moore	Pieridae
25	Mottled Emigrant	*Catopsilia pyranthe* Lin.	Pieridae
26	Pioneer	*Anaphaeis aurota aurota* Fabricius	Pieridae
27	Yellow Orangetip	*Ixias pyrene familiaris* Butler	Pieridae
28	Common Fivering	*Ypthima baldus baldus* Fabricius	Satyridae
29	Common Bushbrown	*Mycalesis perseus blasius* Fabricius	Satyridae
30	Common Eveningbrown	*Melanitis leda ismene* Cramer	Satyridae

4.5.2. Amphibians and reptiles

Seven species of amphibians (Table 9) and 12 of the reptiles (Table 10) were observed in the vicinity of the proposed pipeline during the sampling period. Among the reptiles, three species are highly water dependant or aquatic. Most of the reptiles and amphibians found in the project area are highly adaptable

and have wider distribution elsewhere in India. Most of them are commensals in human habitations.

Table 9. Amphibians observed along the HBJ PH. III pipeline route

No.	Scientific name	English name
1	*Bufo melanostictus*	Common Asian Toad
2	*Bufo stomaticus*	Marbled Toad
3	*Euphlyctis cyanophlyctis*	Indian Skipper Frog
4	*Limnonectes limnocharis*	Cricket Frog
5	*Tomopterna breviceps*	Short-headed Burrowing Frog
6	*Hoplobatrachus tigerinus*	Indian Bull Frog
7	*Microhyla ornate*	Ornate Narrow-mouthed Frog
Nomenclature following Das and Dutta (1998)		

Table 10. Reptiles observed along the HBJ PH. III pipeline route

No.	Scientific name	English name
1	Lissemys punctata#	Indian Flapshell Turtle
2	Aspideretes gangeticus#	Indian Softshell Turtle
3	Hemidactylus flaviviridis	Yellow-green House Gecko
4	Sitana ponticeriana	Fanthroated Lizard
5	Calotes versicolor	Indian Garden Lizard
6	Mabuya carinata	Keeled Grass Skink
7	Lygosoma punctatus	Spotted Supple Skink
8	Varanus bengalensis	Bengal Monitor
9	Ptyas mucosus	Indian Rat Snake
10	Xenochropis piscator#	Checkered Keelback Water Snake#
11	Naja naja	Spectacled Cobra
12	Echis carinatus	Saw scaled Viper
# Water dependent species, Nomenclature after Das (1997)		

4.5.3. Birds and mammals

Ninety-six of birds (Table 11) and seven of the mammals (Table 12) were recorded in the environs of the proposed project. Of the 96 species of birds 41 were highly water dependent. Higher number of water birds was due to the presence of wetlands, perennial rivers and well-irrigated fields along certain stretches of the pipeline. In the irrigated agricultural fields Cattle Egrets were common, and in the hill slopes Bank Myna were nesting (Plate 3). Species of water birds such as Sarus Crane were sighted near Dadri. Fewer number of mammal species encountered during the survey was due to the lack of forest cover and the prevailing agricultural and industrial practices along the route.

The major rivers, along their sides, where flow of water is close to stagnancy water- birds are known to frequent during the migratory period. Resident

water-birds are also seen in most of these habitats for most of the seasons in varied numbers. The wetlands along the route also offer valuable habitats for the water dependent and aquatic species seasonally or round the year. As in the case of the flora, the faunal composition around the intermediate compressor stations such as Vijaipur and Dadri are similar to that of the general pipeline route.

Table 11. Birds recorded along the HBJ PH. III pipeline route

No	*Scientific name*	English name
1	*Podiceps ruficollis #*	Little Grebe
2	*Phalacrocorax niger #*	Little Cormorant
3	*Ardeola grayii #*	Pond Heron or Paddy bird
4	*Bubulcus ibis #*	Cattle Egret
5	*Egretta intermedia #*	Smaller (Median) Egret
6	*Egretta garzetta #*	Little Egret
7	*Egretta alba#*	Large Egret
8	*Anastomus oscitans #*	Openbill Stork
9	*Mycteria leucocephala#*	Painted Stork
10	*Threskiornis aethiopica#*	White Ibis
11	*Nycticorax nycticorax #*	Night Heron
12	*Platalea leucorodia#*	Spoonbill
13	*Ardea cinerea #*	Gery Heron
14	*Ardea purpurea#*	Purple Heron
15	*Anas acuta#*	Pintail
16	*Anas querqudela #*	Garganey Teal
17	*Anas creca#*	Common teal
18	*Todorna todorna#*	Brahminy Duck
19	*Anas Penelope#*	Wigeon
20	*Dendrocygna javanica#*	Whistling Teal
21	*Anas poecilorhyncha #*	Spotbill
22	*Nettapus coromandelianus #*	Cotton Teal
23	*Sarkidiornis melanotus#*	Comb Duck
24	*Gyps bengalensis*	Whitebacked Vulture
25	*Neophron percnopterus*	Scavenger Vulture
26	*Elanus caeruleus*	Blackwinged Kite
27	*Milvus migrans*	Pariah Kite
28	*Haliastur indus#*	Brahminy Kite
29	*Accipiter badius*	Indian Shikra
30	*Francolinus francolinus*	Black Patridge
31	*Francolinus pondicerianus*	Grey Patridge
32	*Coturnix sp.*	Quail
33	*Pavo cristatus*	Common Peafowl
34	*Grus antigone#*	Sarus Crane
35	*Prozana fusca#*	Ruddy Crake
36	*Amaurornis phoenicurus #*	Whitebreasted Waterhen
37	*Gallinula chloropus #*	Indian Moorhen
38	*Porphyrio porphyrio#*	Purple Moorhen
39	*Fulica atra #*	Coot
40	*Hydrophaasianus chirurgus#*	Pheasant- tailed Jacana
41	*Metopidius indicus#*	Bronzewinged Jacana

No	Scientific name	English name
42	*Vanellus indicus #*	Redwattled Lapwing
43	*Vanellus malabaricus*	Yellowwattled Lapwing
44	*Tringa totanus #*	Common Sandpiper
45	*Tringa stagnatilis #*	Marsh Sandpiper
46	*Tringa nebularia*	Green Shank
47	*Himantopus himantopus #*	Blackwinged Stilt
48	*Chlidonias hybrida #*	Whiskered Tern
49	*Sterna aurantia#*	River Tern
50	*Columba livia*	Blue Rock Pigeon
51	*Streptopelia decaocto*	Indian Ring Dove
52	*Streptopelia senegalensis*	Little Brown Dove
53	*Streptopelia chinensis*	Spotted Dove
54	*Psittacula krameri*	Rose-ringed Parakeet
55	*Clamator coromandus*	Pied Crested Cuckoo
56	*Cuculus varius*	Brainfever Bird
57	*Eudynamys scolopacea*	Koel
58	*Centropus sinensis*	Crowpheasant
59	*Athene brama*	Spotted Owlet
60	*Caprimulgus sp.*	Nightjar
61	*Cypsiurus parvus*	Palm Swift
62	*Apus affinis*	House Swift
63	*Ceryle rudis #*	Lesser Pied Kingfisher
64	*Alcedo atthis #*	Small Blue Kingfisher
65	*Halcyon smyrnensis #*	Whitebreasted Kingfisher
66	*Merops orientalis*	Small Green Bee-eater
67	*Coracias benghalensis*	Indian Roller
68	*Upupa epops*	Hoopoe
69	*Tockus birostris*	Common Grey Hornbill
70	*Megalaima haemacephala*	Crimsonbreasted Barbet
71	*Dinopium benghalense*	Goldenbacked Woodpecker
72	*Eremopterix grisea*	Ashycrowned Finch Lark
73	*Alauda sp.*	Sky Lark
74	*Hirundo smithii*	Wire-tailed Swallow
75	*Lanius vittatus*	Baybacked Shrike
76	*Lanius schach*	Rufousbacked Shrike
77	*Oriolus oriolus*	Golden Oriole
78	*Dicrurus adsimilis*	Black Drongo
79	*Acridotheres ginginianus*	Bank Myna
80	*Acridotheres tristis*	Common Myna
81	*Sturnus pagodarum*	Brahminy Myna
82	*Sturnus contra*	Pied Myna
83	*Dendrocitta vagabunda*	Tree Pie
84	*Corvus splendens*	House Crow
85	*Corvus macrorhynchos*	Jungle Crow
86	*Pycnonotus cafer*	Redvented Bulbul
87	*Turdoides affinis*	Whiteheaded Babbler
88	*Prinia socialis*	Ashy Wren-warbler
89	*Orthotomus sutorius*	Tailor Bird
90	*Sylvia curruca*	Lesser Whitethroat
91	*Copsychus saularis*	Magpie Robin
92	*Saxicoloides fulicata*	Indian Robin
93	*Saxicola caprata*	Pied Bush Chat
94	*Nectarinia asiatica*	Purple Sunbird

No	Scientific name	English name
95	*Passer domesticus*	House Sparrow
96	*Ploceus philippinus*	Baya
Nomenclature following Ali and Ripley (1983), #Aquatic species		

Table 12. Mammals observed along the pipeline route

No.	Scientific name	English name
1	*Macaca mulatta*	Rhesus Macaque
2	*Presbytis entellus*	Common Langur
3	*Herpestes edwardsi*	Common Indian Mongoose
4	*Herpestes javanicus*	Small Indian Mongoose
5	*Pteropus giganteus*	Indian Flying Fox
6	*Funambulus pennanti*	Five-striped Palm Squirrel
7	*Lepus nigricollis*	Indian Hare
Nomenclature following Prater (1990)		

4.6. ENDANGERED SPECIES

Of the 122 species of vertebrates that were observed in the vicinity of the proposed pipeline project 11 are listed in the Schedule I and II (Table 13) of the Indian Wildlife Protection Act 1972 (Anonymous 1991). This includes two species of mammals, three of birds and six of reptiles. However, only three species are included in the Indian red data book (two vulnerable and one endangered species, ZSI 1994, Table 13). Most of these species found in the project area and its immediate environs are highly adaptable. They are also widely distributed elsewhere in India. Further, none of the vertebrate species observed in the various sectors along the pipeline route are endemic to the corresponding geographical regions.

Table 13. Endangered species observed in the environs of the pipeline route

Species		WPA (1972) Schedule*	Red Data Book **
Mammals			
1	Rhesus Macaque	II	No mention
2	Common Langur	II	No Mention
Birds			
3	Spoonbill	I	No mention
4	Peafowl	I	**Vulnerable**
5	Indian Shikra	I	No mention
Reptiles			
6	Indian Flapshell Turtle	I	**Vulnerable**
7	Indian Softshell Turtle	I	**Vulnerable**
8	Bengal Monitor	II	**Endangered**
9	Checkered-Keelback Water Snake	II	No mention
10	Rat Snake	II	No mention
11	Indian Cobra	II	No mention
*Wildlife Protection Act 1972 (Anonymous 1991), ** ZSI (1994)			

4.7. IMPACT OF THE PIPELINE

The major facilities associated with gas pipeline are the receiving, dispatch, control and distribution centers, and compressor stations. The intermediate compressor stations are installed at appropriate intervals along the gas transmission lines to maintain adequate pressure in the pipeline. Installation of underground pipeline mainly involves surveying, right of way clearing, trenching / ditching, pipe stringing, bending, welding, placement of pipe in the trench, backfilling and cleaning. Coating and installing cathodic protection for corrosion control is necessary in most soils, especially in wet or saline areas. The pipeline will be laid minimum of one meter below the surface (1.7m cover at railway crossings and 1.2m at highway and canal crossings) in a 30m wide RoU to be acquired by GAIL. The total area of the entire RoU is about 2262 ha. After laying the pipes the trenches are filled and covered and the land returned to the owners. The RoU is demarcated by markers, at short intervals, indicating the path and the boundary of the RoU. Regular use of the land by the owners, except planting of large trees and construction of concrete structures, is allowed on the RoU.

Major impacts, in general, of any underground pipeline project during the construction are; i) felling trees in the RoU, ii) the movement of labour and machinery, for trench making, welding and laying the pipes in the trench and hydro testing, such as cranes, welding machinery and transport vehicles, iii) creation of RoU can lead to the invasion of exotic plants which may out-compete the natural vegetation, iv) pipeline installation can also result in habitat fragmentation of natural areas resulting in the loss of species and lowering of bio-diversity, and v) long pipelines can open up less accessible natural areas to human activity.

During the rapid ecological assessment, based on sample survey method, we did not encounter any vegetation patches of ecological importance which may get hampered seriously because of construction and operation of the pipeline. The HBJ Phase III pipeline route passes mainly through agricultural fields and wastelands and does not run through any notable thick vegetation that is undisturbed and where the density of trees is high. Hence, no drastic

alteration in the vegetation, habitat fragmentation or increase in accessibility to wild lands can be expected due to creation of the RoU. Likewise, the chance of invasion of the RoU by exotic plants is also negligible. However, it is to be noted that invasion of *Prosopis juliflora* is rampant, especially in non-agricultural lands, through out the states through which the pipeline passes. The possibility of this species colonizing the RoUs can not be ruled out, unless measures to clear the species, in case necessary from the point of view of monitoring, are regularly undertaken.

The laying of pipeline is comparatively a fast process and the disturbances, except that due to clear felling of trees and movement of machinery, are limited only for a few days at any specific site. It is estimated that 74,083 trees, mainly *Acacia nilotica* and *Dalbergia sissoo* will be uprooted along the RoU during the installation of the pipeline. No endangered, endemic and protected tree species were found along the RoU during the sample survey. Hence, it is assumed that no endangered, endemic and protected tree species will be felled on laying the pipeline. In the stretch of pipeline route falling along existing RoU (eg: Vijaypur–Kota, Vijaipur-Gadepan) no felling of trees is anticipated, since all larger trees along the RoU were cleared during the acquiring of RoU for existing pipeline (Plate 4a). In certain areas where existing RoU will be used (eg., along Gadepan-Kota section) for the proposed pipeline widening the RoU to accommodate the new one necessitate felling trees. In Gadepan -Kota section the width of the existing RoU is only 8m and it will be widened by another 22m.

As noted earlier the pipeline cuts across a number of rivers and streams. During the construction of the pipeline across the rivers there is high possibility of damage to the benthic fauna and flora. This is because a large number of benthic fauna are comparatively less mobile or stationary and cannot move away from the disturbance location where trenches are made to place the pipeline. However, the disturbance arising from the activity is highly restricted to the local site of digging and construction and is almost totally reversible. Since no gaseous emissions or liquid discharges are expected

during the operation of the pipeline the benthic fauna and flora can successfully recolonize the submerged pipeline route.

During the operation phase i.e., once the pipeline is laid, the underground pipeline practically does not pose any threat to the local ecological make-up, except in case of accidents like leakage. Although natural gas on its own is not very toxic for short term exposures, its leakage poses serious fire hazard. Breaches of the RoU due to heavy rain are known to expose the underground pipeline. The possibility of such happenings is high in ravines areas along the flood plain of river Chambal. Leaks or ruptures of pipelines can have significant impacts in the immediate vicinity of the pipelines. The primary cause of pipeline accidents, implicated in more than half of all accidents, is outside forces such as careless operation of mechanical equipment, landslides or earth quakes and also deliberate damages (World Bank 1991). As the gas being transported is natural gas, non-toxic and lighter than air it is not expected to cause significant direct harm to flora and fauna in case of brief leakages. In the case of fire, chances of that are rare, but not improbable, due to numerous in-built safety features, damage to immediate nearby flora and fauna is expected. In Haryana and Punjab, burning of the agricultural waste (stubs, hay and straw), left discarded in the agricultural field is a common practice. The practice assist in removal of the waste from the land, control weeds and pests and enrich the field with nutrients released form burning the wastes. The practice results in vast surface fires (Plate 4b). An exposed pipeline and a leakage of the gas can lead to notable consequences in such conditions. Taking note of the low toxicity of the gas, low chances of leakage and fire an attempt was made to develop an impact evaluation matrix in the case of the proposed HBJ Ph. III pipeline. Although in developing these matrices worst-case scenarios were assumed, the exercise shows that during both the construction and operation phase the possible impacts are low (Appendix 5 & 6).

4.8. SENSITIVE AREAS

As noted earlier considerable variations are seen in the ecological setup of the various sectors of the pipeline. An attempt to grade the ecological sensitivity / significance of each sector based on the number of schedule I & II animals present in the area, and vegetation status of the area was made. The exercise suggest (Appendix 7) that the route is comparatively low in ecological sensitivity.

As noted earlier along the pipeline route several wetlands and Reserve Forests were seen in the vicinity (>5 km). The wetlands support waterfowl species such as Sarus Crane, fish-eating birds such as storks, cormorants and egrets, and herbivorous species such as ducks, teals and coots. Waterfowl such as Whistling Teal, Cotton Teal, Brahminy Duck, Pintail, Comb Duck, Spotbill and Dabchick are also seen in these wetlands. No mangroves were seen along the pipeline route (Appendix 11).

4.9. MITIGATORY MEASURES

4.9.1. Minimizing the disturbance

Laying the pipeline need to be done within a short span of time, especially in areas close to the wetlands and vegetated areas. Summer and pre-monsoon periods (April - May) are advisable for construction in such areas for reasons such as i) the primary breeding season for majority resident birds commences with monsoon, ii) winter is the main migratory season for birds and, iii) In this area usually during the monsoon and winter the number of bird species are high.

During the construction the labour force need to be instructed not to cause any damage or disturbance to natural vegetation, forests and wildlife by chance come across in the environs. The labour force may be locally recruited. Fuel wood or any feasible fuel for household activities may be supplied to the labour force to check them from collecting fuel-wood from the nearby forests and vegetations. Machinery required for construction may be allowed to be stationed at any particular site only for the minimum required

duration. Leaks and ruptures of pipeline, even though of low probability, can cause explosions and fire, which may have grave impact on the fauna and flora. Proper disaster management planning should be done to meet emergencies.

No liquid discharges or gaseous emissions are expected during the operation of the pipeline. Hence, no mitigatory measures are felt necessary to be discussed. Similarly as no Sanctuary / National Park / Mangroves are encountered along the pipeline route (Appendix 8), no mitigatory measures are suggested to ameliorate possible impacts on these ecologically important locations. Our findings during the sample survey conducted during April-May 2002 suggest that proposed pipeline does not cross spawning, breeding and nesting areas of turtle and sensitive / endemic / endangered aquatic species (Appendix 9). It may also be noted that the pipeline apparently does not fall in the migratory path of mammalian wildlife. Nevertheless, the whole northwestern India falls within the migratory corridor of waterfowl (ducks, geese, waders, cranes) and a number of other land-birds (Appendix 10). As noted above as the proposed pipeline is not known crossing any mangrove area and therefore no cutting or clearing of mangrove is involved (Appendix 11). Laying the pipeline in grassland and semi-arid and arid areas of Madhya Pradesh and Rajasthan may be undertaken during February-May to avoid the breeding seasons of certain birds likely to be seen in these areas. These grasslands owned / maintained by local communities, apart from being an important source of fodder, form important habitats for a number of birds. Fire preventing measures during construction and operation near forests and grasslands should be strictly implemented. Construction work during November- March near wetlands may be avoided, as during these months maximum concentration of migratory waterfowl could be seen in these habitats.

4.9.2. Compensatory afforestation

Uprooting of a large number of trees is the major problem with the construction of pipeline. The Forest conservation act, 1980 (Anonymous

1992, Upadhyay 1995), gives specific guidelines for compensatory afforestation, if the uprooting takes place inside forest. The proposed pipeline route mostly passes through non-forest land. In the case of present pipeline some area of protected forest need to be diverted for RoU (Table 4). A correct assessment of the required diversion of forest lands, if found necessary after the land survey is conducted during which the exact ownership and legal status of the lands is ascertained, is essential. For the diverted area suitable compensatory afforestation in a corresponding area is binding on the project proponents. Further as an environmental conservation measure, GAIL should envisage provisions for afforestation programme to compensate the trees uprooted from the RoU in non-forested lands as well.

Species such as *Acacia nilotica, Dalbergia sissoo, Azadirachta indica, Melia azadirach* and *Parkinsonia aculeatea*, which are native to the area, are recommended for plantation. Native species have long term viability and are adapted to the ambient conditions and local climatic extremes than many exotic species. They are better than many exotics to meet the material requirements, such as fodder and fuel wood, of the local public and also many of their cultural requirements. Native species are also better in offering suited habitats for the local faunal species. Saplings of the species, approximately twenty times the number of uprooted trees may be planted as a compensation for the uprooted trees. A higher ratio is recommended as compensation making an allowance for the wide varying success rate of tree planting exercises. The proposed pipeline mostly passes through semi-arid bio-climatic region where success of the planted saplings are generally low. In case a better success rate could be achieved in the compensatory tree planting it will better the local environment. The local Forest Department nurseries may be contacted to procure sufficient saplings of the suggested species.

The afforestation scheme may include the following programmes;

i) Supply of saplings to local villagers and the land owners; Saplings, approximately twenty times the number of uprooted trees, may be supplied to the land owners to plant as a replacement for the uprooted trees. A suitable incentive also may be offered to promote tree planting.

ii) Plantation in public / Government land found along the route of the pipeline; A large portion of the RoU is passing through open scrub. Simultaneously with the clearing of the RoU, the GAIL may undertake intensive tree planting programme in government lands along the route.

iii) Collaborate with the local Social Forestry division of the Forest Department and undertake plantation programme; Many of the forested areas, which exists within 25km from the RoU, are fit for implementing afforestation programmes. However, the programme may not be concentrated in any particular location, demarcated area or reserve forest. In each of the districts / taluks, through which the pipeline passes, specific areas may be identified in consultation with the Forest Department for implementing the programme.

4.10. COST VS BENEFIT OF UPROOTING THE TREES ON THE RoU

The Forest Conservation Act (1980, as amended in 1992) makes it mandatory for all proposals involving diversification of more than 20 ha of forest lands in plains and more than five hectares in the hills to undertake a cost-benefit analysis to assess the benefit to cost ratio of the project. An objective cost-benefit analysis of a project from an ecological angle is a highly difficult exercise (World Bank 1991a, 1991b). This is because of i) the difficulty in quantifying the environmental impacts in physical terms and ii) even when impacts are measured in physical terms, valuation in monitory terms is difficult or are liable to subjectivity of the evaluator. For cost-benefit analysis the Forest Conservation Act recommends technical judgement as the primary

means to judge environmental losses. Nevertheless, It suggests as a thumb rule Rs. 126.74 lakhs the environmental value of one hectare of fully stocked forest to be accrued within a period of 50 years. A project implemented after causing one hectare loss of fully stocked forest if earns more than Rs 126.74 lakhs within a period of 50 years it may be considered having a positive cost-benefit ratio. According to the density of the forest, the environmental value of the forest is allowed to proportionately decrease. The assumed environmental value loss is also expected to vary with the bank rate. Thus, the present value of the amount Rs. 126.74 lakhs (determined in 1992) would have a current value of Rs. 300 lakhs on a 9% annual rate of increase. However, as the rationale for the monitisation and an accurate definition of a "fully stocked forest" is not provided, except the mention on the tree density in a qualitative fashion, the decision in effect rests almost fully on the technical judgment and expertise of the investigators. It may be noted that tree density in a "fully stocked forest" may vary according to the location. For examples a fully stocked forest in evergreen forest will be differing highly in tree density from a fully stocked forest in a deciduous forest. In essence the concept of fully stocked forest may depend on the ecological space available in a particular location. Hence, the rationale for fixing the environmental value warrant exhaustive discussion by ecologists, administrators and policy makers prior to it being used effectively in cost-benefit analysis.

The cost - benefit analysis of a project should include assessment of two different scenarios, namely i) the "with project" and ii) the "without project" situations (World Bank 1991a). In the case of the present project, in brief, the negative aspects, of the "with project" scenario are acquiring of RoU by the GAIL, clearing the trees along the RoU, loss of habitat and disturbance to birds and the other fauna, alteration in vegetation, and reduction in the source of fuel wood and fodder to the villagers. The primary positive aspect of the project is that the project is proposed to facilitate transport of a comparatively eco-friendly fuel and raw material for industrial use. In India, as the sources of almost all fuels, except fire wood, are concentrated in certain locations, long range transportation of fuel is inevitable. Transport of the fuels in the country mostly is by surface transport. Surface transport apart from consuming the

valuable fuel has a number of ecological, environmental and human health implications. For this reason attention is being given to other modes of transport for the essential fuels for which the country is depending on international market. The transport by means of pipeline offers a welcome alternative in this background.

The transport of natural gas by underground pipeline is highly cost effective and comparatively risk free than other modes of surface transport. The operational cost of pipelines is very low. The pipelines may considerably reduce the pressure on road and rail traffic and also loss of the material being transported to the environment in transit. The pipeline mode of transport is regarded safest and reliable and less prone to human errors because of the high level of automation. The pipeline mode of transport in comparison with other means such as road or rail is considerably less damaging to the environment. The damages arising from pipeline project is by and large confined to the construction period while in normal operation phase the damage is inconsequential. The operation of the pipeline do not cause noise, emissions or discharges unlike other modes of surface transport.

Subsequent to the installation of the pipeline the land is returned back to the owners and they are free to use the area as they wish with only certain regulations. Hence, the landuse pattern, along the RoU, remains almost the same with only minor restrictions. Except for the markers, which are erected at frequent intervals, the RoU will not stand conspicuous and it more or less will blend with the surroundings. Further the GAIL gives suitable compensation to the landowners for gaining the right of use, which is an additional income to the villagers. The clearing of trees will have only minor effect on the fauna in terms of habitat loss since, the trees are dispersed more or less uniformly along the entire stretch, similar habitat is available adjacently, and major part of the land through which the pipeline passes are agricultural or waste land with low density of trees. Similarly the loss of fuel and fodder to the villagers due to uprooting trees is less, since the number of trees to be felled in each location is low. In a long-term perspective the tree

plantation programme as discussed in earlier sections can help to compensate for these losses.

In the case of the "without project" scenario the positive aspect is that the trees along the RoU will remain intact. The habitat loss, even though minor with the project will be none without the project. The source of fuel wood and fodder may remain unaltered. These benefits, in contrast to the "with project" scenario, is inadequate. The natural gas as a source of fuel and industrial raw material relieves pressure from the domestic and industrial users on fuel wood and other sources of fuel. Natural gas, containing lower sulphur content, is environment friendly than other commonly used fuels. Relieving the pressure on fuel wood may save vast areas of greenery around human habitations and forests. Relieving the pressure from the tankers on the road will lead to better atmospheric environment and also lesser hazards to the road users in the coming years.

5. CONCLUSIONS

1) The Gas Authority of India Limited (GAIL) proposes to upgrade the existing HBJ pipeline. The majority of the route require acquiring new RoU. In Vijaipur-Kota section the pipeline mostly follows the RoU of existing pipelines. The pipeline is laid to transport natural gas. The present study covers the impact of the project on flora and fauna and related ecological aspects.

2) The entire route of the pipeline was examined following sample survey method during April and May 2002. Based on a preliminary examination of the route locations for intensive study were identified. In those locations at an interval of approximately 15-20 km quadrats were marked for intensive study of flora and fauna.

3) Majority of the sampled area, along the route, was agricultural lands, followed by waste-land with neither forest nor agriculture.

4) No rare, endangered or threatened species of plants were located along the route. 105 species of plants were recorded along the path of the pipeline and its environs during the sampling.

5) *Acacia nilotica, Dalbergia sissoo* and *Eucalyptus* sp were the numerically dominant trees along the route. Around 74,083 trees are estimated to be uprooted along the route (considering the width of the RoU to be cleared as 30m).

6) As an environmental conservation measure, GAIL should envisage provisions for afforestation programme to compensate the loss of natural vegetation and also the uprooted trees. Apart from the measures required as per forest conservation act the afforestation scheme may include the following programmes; i) supply of saplings to local villagers and the land owners, ii) plantation in public / Government land along the route of the pipeline, and iii) collaborate with the local Social Forestry division of the Forest Department and undertake plantation programme.

7) Of the 122 species of vertebrates were recorded during the survey, eleven species were listed in schedule I & II of the wildlife protection. However,

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Appendix 1. Grading scheme for assessment of ecological sensitivity of an area

Parameter		Grade / Weightage
Wildlife importance (Endangered species*)	Number of Schedule I & II species (> 20 numbers)	100
	Number of Schedule I & II species (10 - 20 numbers)	50
	Number of Schedule I & II species (< 10 numbers	25
Floral endemicity	High (>10 species)	100
	Medium (5-10 species)	50
	Low (< 5 species)	25
Faunal endemicity	High (>10 species)	100
	Medium (5-10 species)	50
	Low (< 5 species)	25
State of terrestrial vegetation	Relatively undisturbed forest (govt. / private)	100
	Totally managed estate with three tyre vegetation	50
	Totally managed estate such as coffee and cardamom.	25
	Agricultural land with crops such as coconut	0
State of wetland vegetation	Relatively undisturbed wetland visited by migratory waterfowl	100
	Relatively undisturbed wetland not known to be visited by migratory waterfowl	50
	Other wetlands with frequent human activity	25
	Agricultural land with crops such as paddy	10
Legal Status	National Park	100
	Wildlife sanctuary	50
	Reserve forest / Wetland	25
	Agricultural land	0
Conservation importance	Location unique in terms of habitat (such as world heritage site) or species	100
	Habitat although present elsewhere is under threat in those places	75
	Habitat present elsewhere and is not under any serious threat	50
	Habitat is very common elsewhere	25
	Habitat is very common and does not posses any ecological characteristics which needs attention	0
Note: * Species included in Schedule I & II of Wildlife Protection Act, 1972		

Appendix 2. Landuse along the pipeline route

Land use class/ type	Pipeline sectors											Terminals/Int. Comp.stn.										
	1	2	3	4	5	6	7	8	9a	9b	10	A	B	C	D	E	F	G	H	I	J	K
Agriculture (irrigated)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Agriculture (unirrigated)	N	N	N	N	Y	N	N	N	Y	Y	N	N	N	N	N	N	N	N	N	N	Y	N
Homestead	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Forest	N	N	Y	N	Y	N	Y	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N
Notified industrial Area/Estate	N	N	N	N	N	N	N	N	Y	N	N	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y
Grazing	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Fallow	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Orchards	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mangroves	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Sand dunes	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Inter Tidal Zone	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Urban Areas	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
National Park/ Sanctuary	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Existing Right of Use	Y	N	Y	N	N	Y	N	Y	Y	Y	Y	N	N	N	N	N	Y	Y	N	N	N	Y
Waterbody	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Sea	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Flood plains	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

Pipeline Sectors: 1. Dadri - Sonipat; 2. Sonipat - Panipat; 3. Panipat – Sangrur; 4. Sangrur - Ludhiana; 5. Ludhiana - Nangal; 6. Sangrur - Bathinda; 7. Chor Karsa - Yamunanagar; 8. Faridabad – Bahadurgargh; 9a. Vijaipur – Gadepan; 9b Gadepan -Kota; 10. Ibrahimpur - Dhoulpur**Terminals/Compressor station:** A. Vijaipur compressor station; B. Kota; C. Chainasa; D. Bahadurgargh; E. Faridabad; G. Dhoulpur; H. Yamunanagar; I. Bhatinda; J. Nangal; K. Dadri; N = Does not exist; Y = Present

Appendix 3. List of plant species recorded along the pipeline route and its environs

No.	Species	Habit	Occurrence of tree
1	*Abutilon hirtum*	Shrub	
2	*Acacia leucopholea*	Tree	8
3	*Acacia nilotica*	Tree	1,2,3,6,7,8,9,10
4	*Acacia sp*	Tree	6
5	*Achyranthes aspera*	Herb	
6	*Agave americana*	Shrub	
7	*Ailanthus excelsa*	Tree	3,7,8
8	*Albizzia lebbeck*	Tree	5
9	*Alhagi maurorum*	Herb	
10	*Allium cepa*	Herb	
11	*Amaranthus spinosus*	Herb	
12	*Amaranthus viridis*	Herb	
13	*Ammania sp*	Herb	
14	*Argemone mexicana*	Herb	
15	*Azadirachta indica*	Tree	1,3,5,6,8
16	*Balanites aegyptaca*	Tree	3
17	*Bambusa arundinacea*	Tree	8
18	*Kigelia pinnata*	Tree	5
19	*Boerhavia diffusa*	Herb	
20	*Boerhavia erecta*	Herb	
21	*Bogainvillea glabra*	Shrub	
22	*Bombax ceiba*	Tree	7
23	*Brassica nigra*	Herb	
24	*Broussonetea payerifolia*	Tree	3
25	*Butea monosperma*	Tree	7
26	*Brassica oleracea var capitata*	Herb	
27	*Callistemon citrinus*	Tree	8
28	*Calotropis gigantea*	Shrub	
29	*Cannabis sativa*	Herb	
30	*Capparis decidua*	Tree	1,3,9
31	*Capparis sepiaria*	Shrub	
32	*Carica papaya*	Tree	10
33	*Cassia occidentalis*	Herb	
34	*Cassia siamea*	Tree	5,7,8
35	*Celosia argentea*	Herb	
36	*Chenopodium ambrosoides*	Herb	
37	*Chenopodium murale*	Herb	
38	*Chloris barbata*	Herb	
39	*Chrozophora rottleri*	Herb	
40	*Cocculus hirsutus*	Climber	
41	*Coronopus didymus*	Herb	
42	*Croton sparciflorus*	Herb	
43	*Cucumis sp*	Climber	
44	*Cuscuta reflexa*	Parasite	
45	*Cynodon dactylon*	Herb	
46	*Dalbergia sissoo*	Tree	1,3,4,5,7,8,9
47	*Datura metel*	Shrub	
48	*Digitaria bicornis*	Herb	
49	*Echinops echinatus*	Herb	
50	*Eichhornia crassipes*	Herb	
51	*Emilia sp*	Herb	
52	*Enterolobium saman*	Tree	7
53	*Eragrostis viscosa*	Herb	
54	*Eucalyptus sp*	Tree	1,3,4,5,6,7,9

No.	Species	Habit	Occurrence of tree
55	*Euphorbia hirta*	Herb	
56	*Euphorbia rosea*	Herb	
57	*Feronia elephantum*	Tree	9
58	*Gompherena celosioides*	Herb	
59	*Grevillea robusta*	Tree	8
60	*Grewia sp*	Shrub	
61	*Heliotropium sp*	Herb	
62	*Hordeum vulgare*	Shrub	
63	*Hydrilla verticillata*	Herb	
64	*Ipomoea carnea*	Shrub	
65	*Justicia betonica*	Shrub	
66	*Kirganelia reticulata*	Shrub	
67	*Lantana camara*	Shrub	
68	*Lawsonia inermis*	Shrub	
69	*Lycopersicon lycopersicum*	Shrub	
70	*Malvastrum coromandelianum*	Herb	
71	*Mangifera indica*	Tree	4
72	*Melia azadirach*	Tree	4,5,8
73	*Murraya koenigi*	Shrub	
74	*Nerium oleander*	Shrub	
75	*Ocimum sp*	Herb	
76	*Oxalis corniculata*	Herb	
77	*Panicum brevifolium*	Herb	
78	*Parkinsonia aculeatea*	Tree	6
79	*Parthenium hysterophorus*	Herb	
80	*Phoenix sylvestris*	Tree	1,5
81	*Phragmites kurka*	Shrub	
82	*Pongamia pinnata*	Tree	7,10
83	*Populus ciliata*	Tree	3,4,5,7
84	*Prosopis cineraria*	Tree	6
85	*Prosopis juliflora*	Tree	2,3,6,7,9,10
86	*Ricinus communis*	Shrub	
87	*Saccharum officinarum*	Shrub	
88	*Saccharum spontaneum*	Shrub	
89	*Salvadora oleoides*	Tree	3
90	*Sida cordata*	Herb	
91	*Solanum indicum*	Herb	
92	*Sonchus oleraceus*	Herb	
93	*Spirodela sp*	Herb	
94	*Syzygium cumini*	Tree	7,9
95	*Terminalia sp*	Tree	6
96	*Tragus roxburghii*	Herb	
97	*Triumfetta annua*	Herb	
98	*Triumfetta rotundifolia*	Herb	
99	*Vernonia cinerea*	Herb	
100	*Vinca rosea*	Herb	
101	*Withania somnifera*	Herb	
102	*Xanthium strumarium*	Shrub	
103	*Zea mays*	Shrub	
104	*Zizyphus mauritiana*	Tree	3,4,6
105	*Zizyphus nummularia*	Shrub	

No.	Section/Species	Mean GBH	Mean Height	No. to be felled	Percentage
	Total			5227	100
7 Chor Karsa - Yamunanagar (80 km)					
1	*Acacia nilotica*	88.3	10.6	1152	6
2	*Ailanthus excelsa*	110	12	192	1
3	*Bombax ceiba*	66.6	4.3	576	3
4	*Cassia siamea*	20	4	192	1
5	*Dalbergia sissoo*	83.75	11.5	768	4
6	*Eucalyptus* sp	76.92	12.42	9600	52
7	*Pongamia pinnata*	65	5	192	1
8	*Populus ciliata*	50.8	12.3	4032	22
9	*Prosopis juliflora*	51.25	4.87	1536	8
10	*Syzygium cumini*	70	10	192	1
	Total			18432	100
8 a) Faridabad - Gurugaon (55 km)					
1	*Acacia leucopholea*	53	5	135	3.4
2	*Acacia nilotica*	57.6	6	2025	51.7
3	*Ailanthus excelsa*	46.2	5.7	540	13.8
4	*Azadirachta indica*	20	3	135	3.4
5	*Cassia siamea*	50.5	5	540	13.8
6	*Dalbergia sissoo*	63.3	6	405	10.3
7	*Melia azadirach*	25	3	135	3.4
	Total			3915	100
8 b) Gurugaon – Bahadurgargh (45km)					
1	*Acacia nilotica*	0.5	2	330	11.1
2	*Ailanthus excelsa*	3.5	14	2310	77.8
3	*Dalbergia sissoo*	0.5	2	330	11.1
	Total			2970	100
9a Vijaipur – Gadepan - Follow already existing RoU					
9b Gadepan - Kota					
1	*Acacia nilotica*	54	5.2	883	31
2	*Dalbergia sissoo*	70	8	80	3
3	*Eucalyptus* sp	75.5	10.9	803	28
4	*Feronia elephantum*	20	3	80	3
5	*Prosopis juliflora*	29	4.3	803	28
6	*Syzygium cumini*	90	9.3	241	8
	Total			2889	100
10 Ibrahimpur -Dhoulpur (28 km)					
1	*Acacia nilotica*	22.5	3	336	40
2	*Carica papaya*	45	4	168	20
3	*Pongamia pinnata*	30	4	168	20
4	*Prosopis juliflora*	55	6	168	20
	Total			840	100
Total for all pipeline sections				74083	

Appendix 5. Environmental Impact evaluation matrix (Construction phase)

Aspects		Impact on				
		Flora		Fauna		
		Trees	Others	Mammals	Birds	Herpetofauna
Pipeline	Acquisition of RoU	1.00	1.00	1.00	2.00	0.00
	Clearing the RoU	7.00	2.00	2.00	2.00	3.00
	Trenching	0.00	3.00	2.00	2.00	3.00
	Machinery and materials mobilization	2.00	3.00	2.00	1.00	3.00
Intermediate pumping station	Site clearance and levelling	7.00	2.00	1.00	2.00	6.00
	Construction and erection	1.00	1.00	1.00	2.00	4.00
Workforce demands	Transportation	0.00	0.00	0.00	0.00	0.00
	Communication	0.00	0.00	0.00	0.00	0.00
	Power / Fuel	0.00	0.00	0.00	0.00	0.00
	Supportive infrastructure and other facilities such as medical and educational	4.00	2.00	0.00	0.00	3.00
Note: Graded from 0-10 based on the severity of the impact; 0 denotes no impact and 10 very severe impact						

Appendix 6. Environmental Impact evaluation matrix (Operation phase)

Aspects		Impact on				
		Flora		Fauna		
		Trees	Others	Mammals	Birds	Herpetofauna
Pipeline	Inspection and maintenance	0.00	2.00	1.00	1.00	2.00
	Pipeline operation	0.00	0.00	0.00	0.00	0.00
	Work force demands	0.00	0.00	0.00	0.00	0.00
Intermediate pumping station	Terminal operation	0.00	0.00	1.00	1.00	0.00
	Product storage	0.00	0.00	0.00	0.00	0.00
	Product pumping	0.00	0.00	0.00	0.00	0.00
	Workforce requirements	2.00	3.00	2.00	1.00	1.00
Note: Graded from 0-10 based on the severity of the impact; 0 denotes no impact and 10 very severe impact						

Appendix 7. Ecological sensitivity of the pipeline route

Parameter	Grade
Wildlife importance (endangered species*)	50
Floral endemicity	0
Faunal endemicity	0
State of terrestrial vegetation	0
State of wetland vegetation	25
Legal status	0
Conservation importance	0
Total	75
Note: * Species included in Schedule I & II of Wildlife Protection Act, 1972	

Appendix 8. Existence/ location of ecologically sensitive areas in the vicinity of the pipeline , intermediate stations and terminals

Ecological Area Type	Name and aerial distance (km) from the proposed pipeline/facility																			
	Pipeline sectors										Terminals / Intermediate Compressor Station.									
	1	2	3	4	5	6	7	8	9	10	A	B	C	D	E	F	G	H	I	J
National Park	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Marine Park	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Sanctuary	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Tiger Reserve	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Elephant Reserve	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Core zone Biosphere Reserve	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Reserve Forest/Protected forest	N	N	Y	N	Y	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N
Wildlife Habitat	N	N	Y	N	Y	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N
Habitat of endangered/endemic species	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N
Coral reef / coastal area	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mangroves	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Lakes/Reservoirs/ Dam	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N
Habitat of Migratory waterfowl	N	N	N	N	Y	N	N	N	Y	N	N	N	N	N	N	N	N	N	Y	N
Natural lakes/swamps	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

Pipeline Sectors: 1. Dadri - Sonipat; 2. Sonipat - Panipat; 3. Panipat - Sangrur; 4. Sangrur - Ludhiana; 5. Ludhiana - Nangal; 6. Sangrur - Bathinda; 7. Chor Karsa - Yamunanagar; 8. Faridabad – Bahadurgargh; 9. Vijaipur - Kota; 10. Ibrahimpur – Dhoulpur; **Terminals/Compressor station**: A. Vijaipur compressor station; B. Kota; C. Chainasa; D. Bahadurgargh; E. Faridabad; F. Dhoulpur; G. Yamunanagar; H. Bhatinda; I Nangal; J. Dadri ; N = Does not exist; Y = Present

Appendix 9. Existence of any spawning, breeding , nesting or nursery area of turtles and or other aquatic species near the proposed pipeline route

Details	Pipeline sectors										Terminals/Int. Comp.stn.									
	1	2	3	4	5	6	7	8	9	10	A	B	C	D	E	F	G	H	I	J
1. Spawning, breeding, nesting or nursery area of turtles	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
2. Spawning, breeding, nesting or nursery area of sensitive/ endemic /endangered aquatic species	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Pipeline Sectors: 1. Dadri - Sonipat; 2. Sonipat - Panipat; 3. Panipat - Sangrur; 4. Sangrur - Ludhiana; 5. Ludhiana - Nangal; 6. Sangrur - Bathinda; 7. Chor Karsa - Yamunanagar; 8. Faridabad - Bahadurgargh; 9. Vijaipur - Kota; 10. Ibrahimpur - Dhoulpur**Terminals/Compressor station:** A. Vijaipur compressor station; B. Kota; C. Chainasa; D. Bahadurgargh; E. Faridabad; F. Dhoulpur; G. Yamunanagar; H. Bhatinda; I Nangal; J. Dadri; K. DadriN = Does not exist; Y = Present																			

Appendix 10. Existence of any migratory path/route of animals/birds crossed by the proposed pipeline route

Ecological type area	Pipeline sectors										Terminals/Int. Comp.stn.									
	1	2	3	4	5	6	7	8	9	10	A	B	C	D	E	F	G	H	J	K
1. Migratory path of animals	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
2. Migratory route of birds*	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Pipeline Sectors: 1. Dadri - Sonipat; 2. Sonipat - Panipat; 3. Panipat - Sangrur; 4. Sangrur - Ludhiana; 5. Ludhiana - Nangal; 6. Sangrur - Bathinda; 7. Chor Karsa – Yamunanagar; 8. Faridabad - Bahadurgargh; 9. Vijaipur - Kota; 10. Ibrahimpur - Dhoulpur**Terminals/Compressor station:** A. Vijaipur compressor station; B. Kota; C. Chainasa; D. Bahadurgargh; E. Faridabad; ; F. Dhoulpur; G. Yamunanagar; H. Bhatinda; I Nangal; J. Dadri; N = Does not exist; Y = Present*The whole northwestern India forms the migratory corridors for wintering birds such as ducks, geese, waders and land birds. Bird migration largely occurs during September - November and March-April.																			

Appendix 11.Cutting/removal of mangroves by the proposed pipeline route

Ecological type area	Pipeline sectors										Terminals/Int. Comp.stn.									
	1	2	3	4	5	6	7	8	9	10	A	B	C	D	E	F	G	H	I	K
Cutting/ removal of mangroves	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

Pipeline Sectors: 1. Dadri – Sonipat; 2. Sonipat - Panipat; 3. Panipat - Sangrur; 4. Sangrur - Ludhiana; 5. Ludhiana - Nangal; 6. Sangrur - Bathinda; 7. Chor Karsa - Yamunanagar; 8. Faridabad - Bahadurgargh; 9. Vijaipur - Kota; 10. Ibrahimpur – Dhoulpur**Terminals/Compressor station:** A. Vijaipur compressor station; B. Kota; C. Chainasa; D. Bahadurgargh; E. Faridabad; F. Dhoulpur; G. Yamunanagar; H. Bhatinda; I Nangal; J. Dadri; N = Does not exist; Y = Present

Plate 1 a) Pipeline traverses largely through agricultural fields
b) A view of Poplar plantation near Yamunanagar

Plate 2 a) The pipeline passes through hill forest along the Ludhiana – Nangal sector
b) A view of Yamuna canal in the vicinity of the proposed pipeline crossing

Plate 3 a) Bank Myna, a common bird species seen along the pipeline route
b) Cattle Egret, is common along the wet agricultural fields

Plate 4 a) The proposed pipeline in many places goes along the existing pipeline RoU
b) Surface man-made fire is common in the agricultural fields along the pipeline