



Maps and Annex

WILDLIFE CONSERVATION PLAN FOR
SCHEDULE-I SPECIES FOR Onshore Oil
& Gas development drilling and
production in Tinsukia and Dibrugarh
Districts under Hugrijan, Naharkatia &
Naharkatia Extension, Sapkaint and few
parts of Dumduma (Block A&B), Borhat
and Moran Extension PMLs (Jorajan
Block)



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(भारत सरकार का उद्यम)
Oil India Limited
(A Government of India Enterprise)

Figure 1.1 Regional Setting Map of Jorajan Block

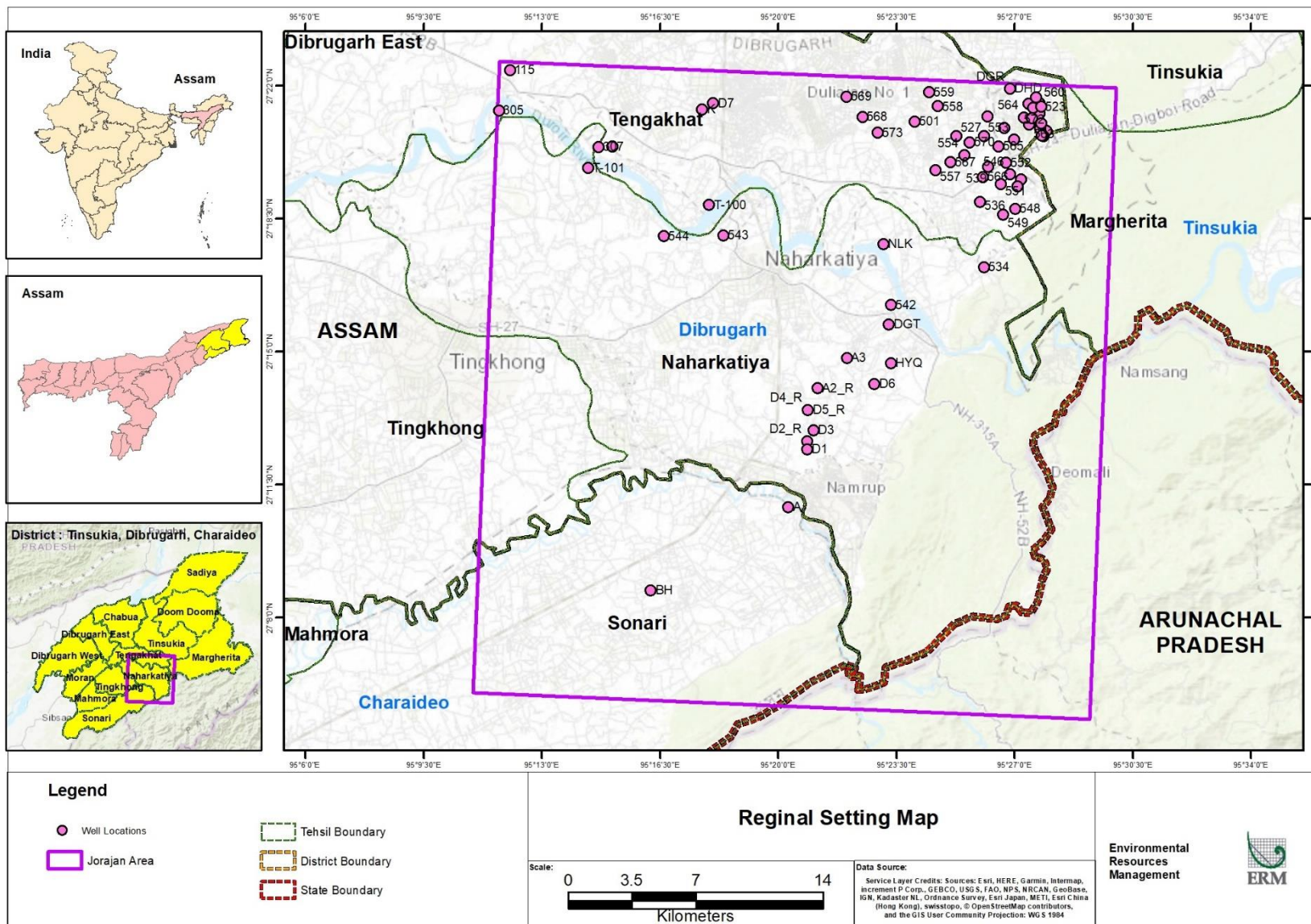


Figure 2.1 Topography Map

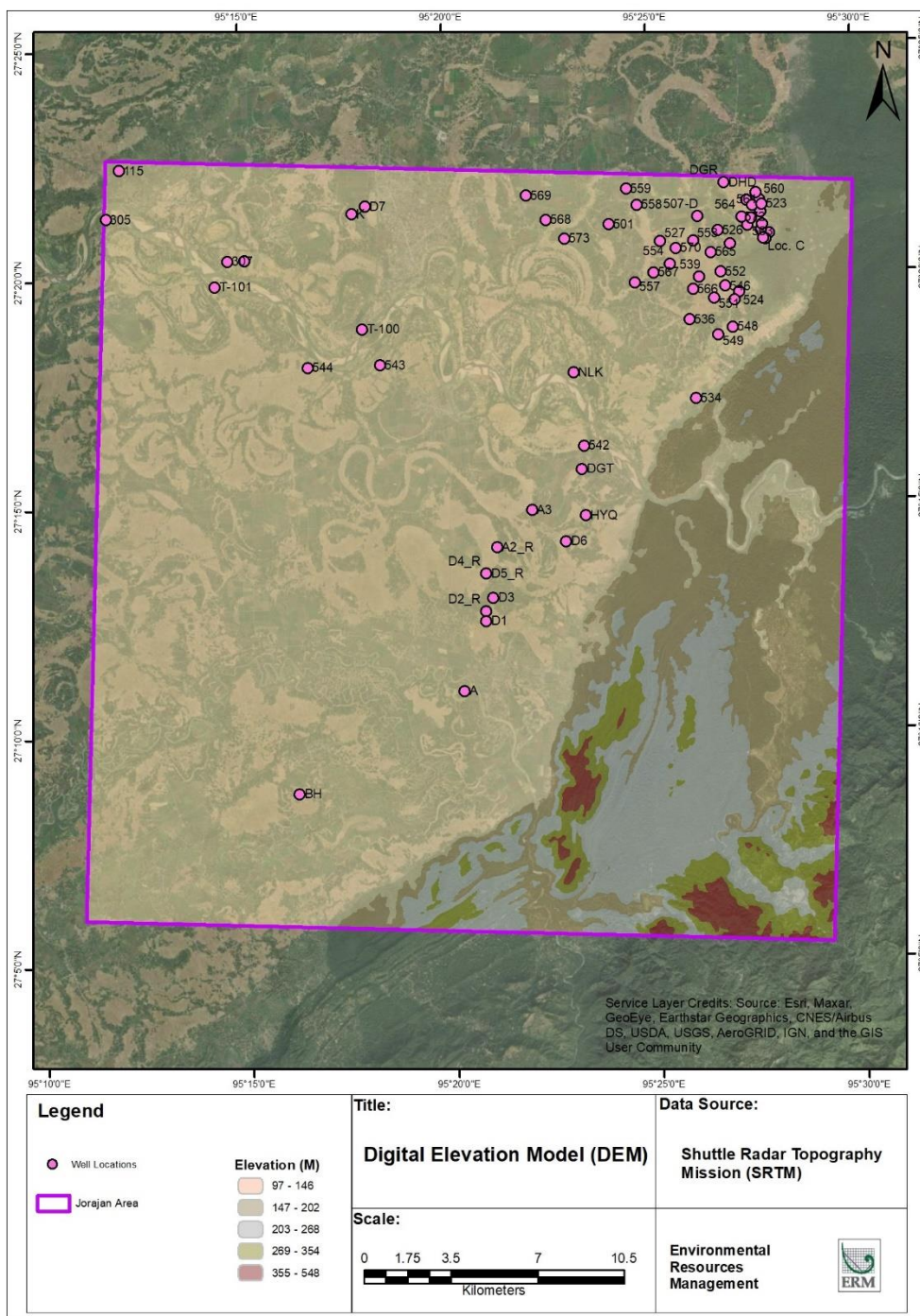


Figure 2.2 Distribution of land use and land cover in the Study Area

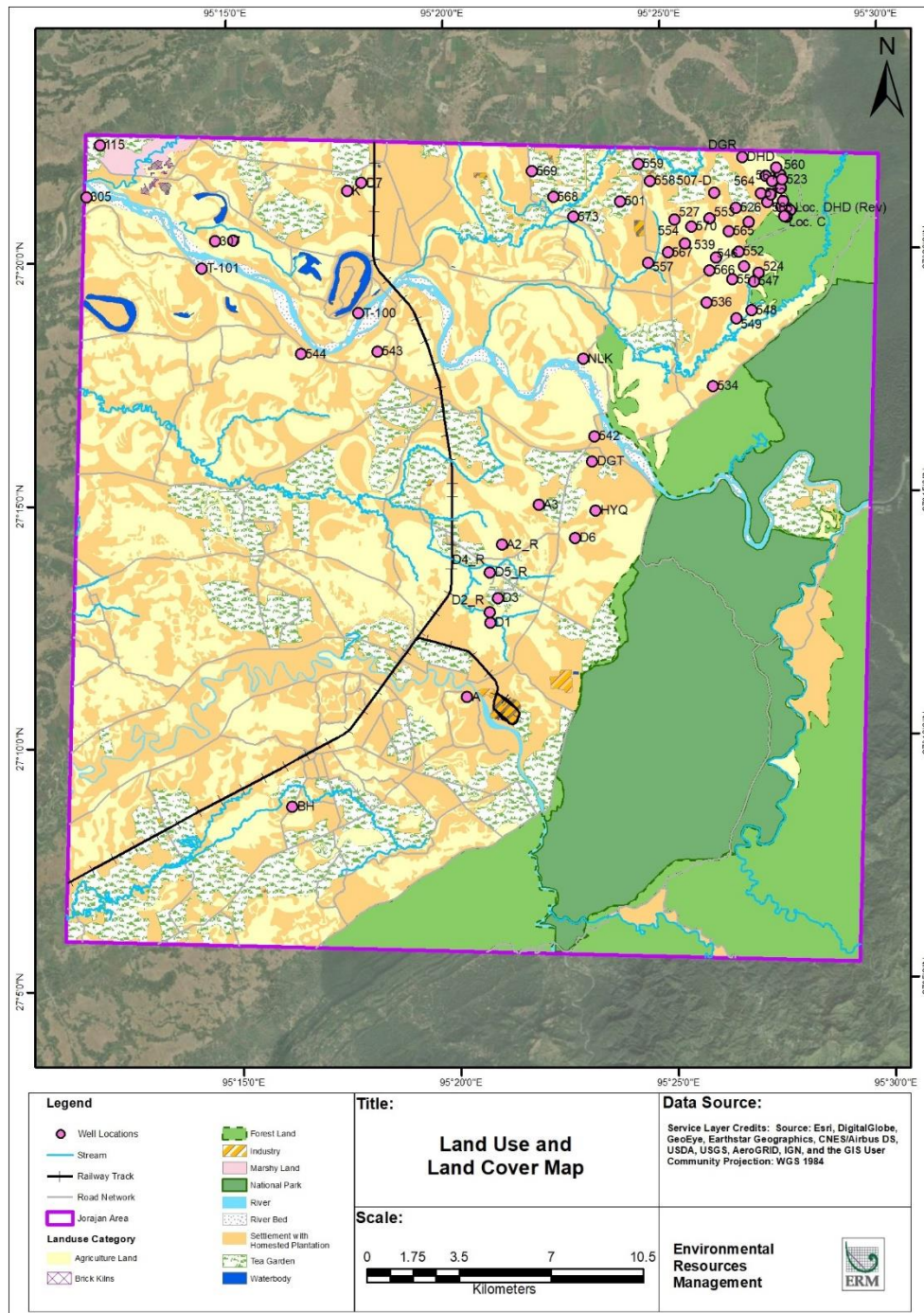
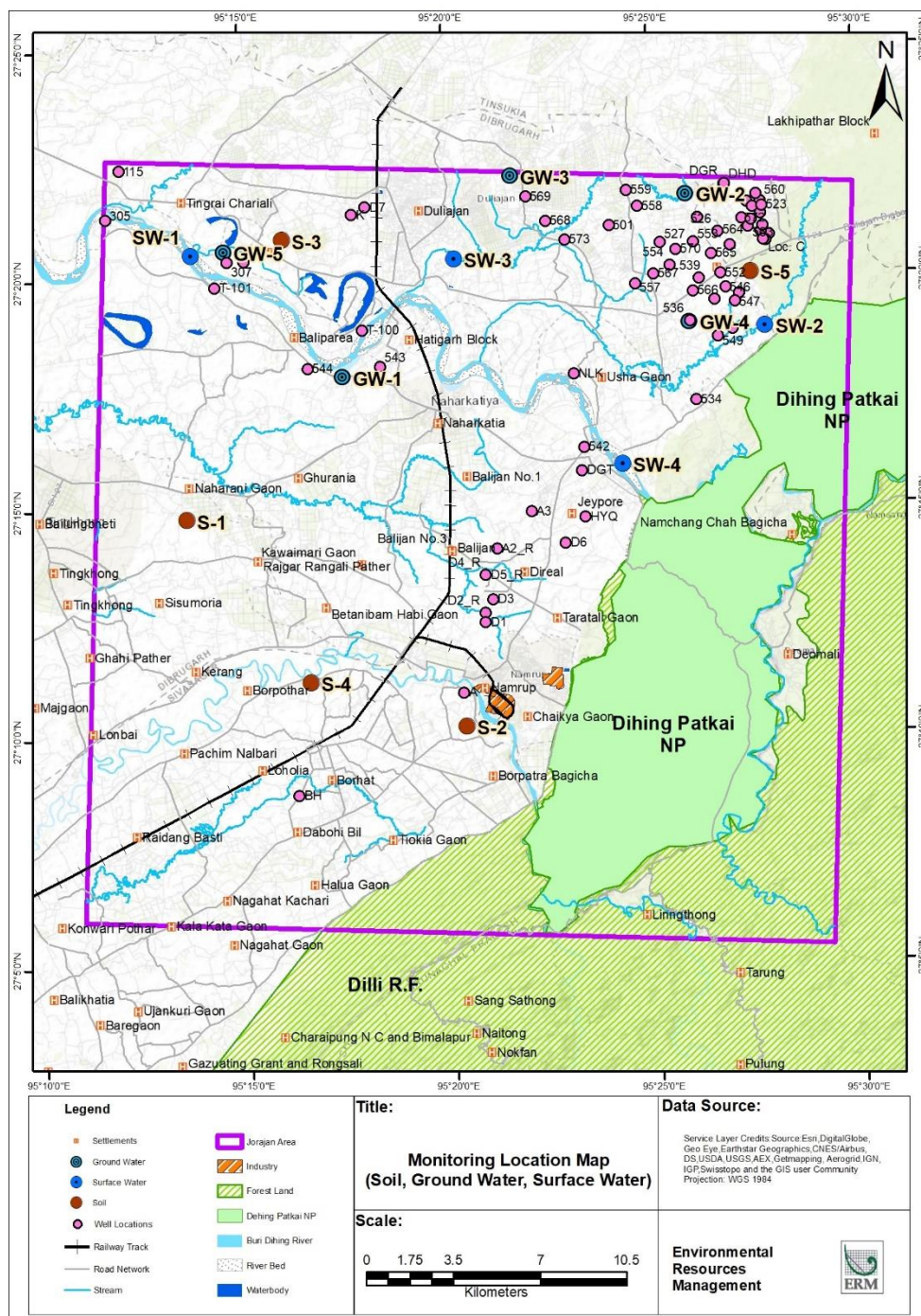


Figure 2.3 Soil, Groundwater and Surface water Monitoring Locations



Climate and Meteorology

The study area falls under the humid sub-tropical climate zone with warm seasons.

An automatic micro-meteorological station was installed at Naharkatia during the study area. The parameters monitored included wind speed, wind direction, ambient temperature, relative humidity, rainfall. The maximum and minimum temperature reported during the study period was 29°C and 11°C. The average temperature was in the range of 19.8°C during the study period.

Figure 2.5 Air, Noise, Met and Traffic Monitoring Locations

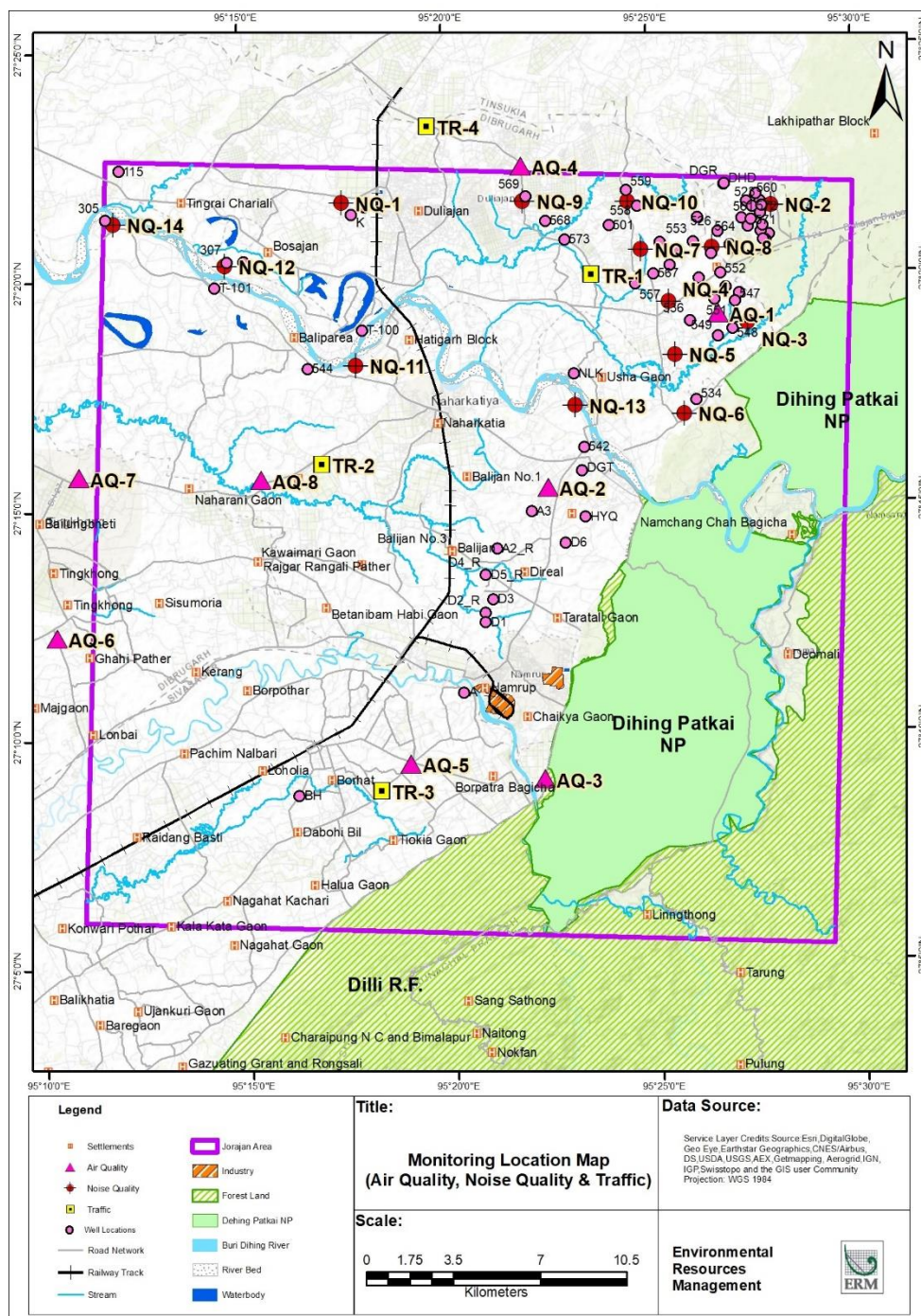
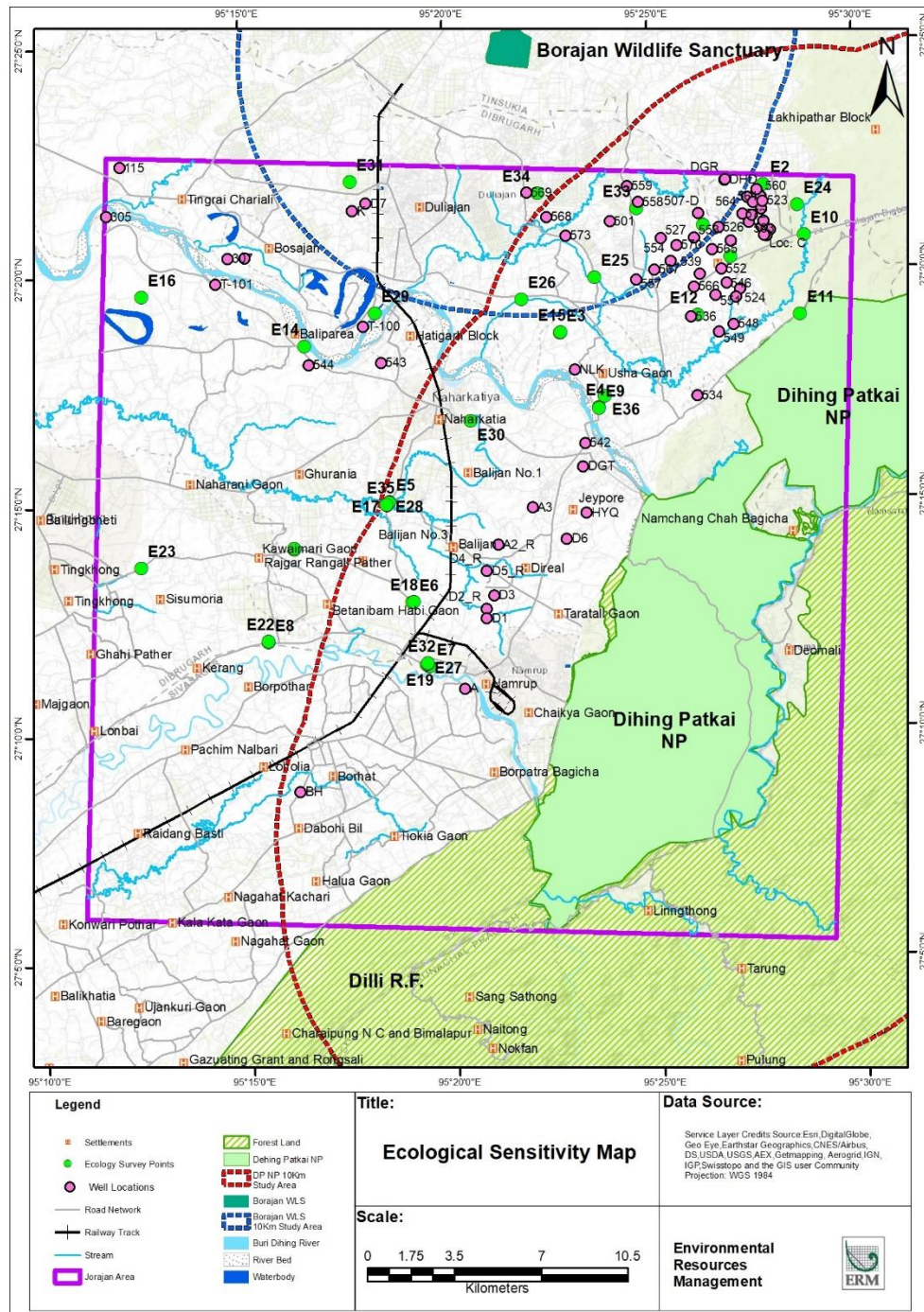


Figure 2.9 Ecological Sensitivity Map



ANNEXURE 1

Environmental Monitoring Location Details

A. Soil Monitoring Locations in Study Area

S. No.	Monitoring Location	Station Number	Land Use	Latitude	Longitude
1.	Barpathar	S1	Homestead Plantation	27° 14' 46.570" N	95° 13' 35.556" E
2.	Near Janglu kuruka	S2	Agriculture land	27° 10' 11.103" N	95° 20' 20.875" E
3.	Namrup Cha bagicha (Santipur)	S3	Tea Garden	27° 6' 46.207" N	95° 11' 44.067" E
4.	Lakhi PatherArea	S4	Forest	27° 11' 11.605" N	95° 16' 33.906" E
5.	Chetia pather	S5	Tea Garden	27° 20' 0.393" N	95° 27' 28.786" E

Source: ERM Primary Monitoring

B. Air Monitoring Locations

SI No	Monitoring Location Number	Geo-coordinates	Rationale for Selection
AQ1	Chapatali	27° 15' 37.653" N 95° 15' 25.558" E	At the centre of the drilling locations; downwind of most of the locations at north eastern corner of the Block. Upwind to locations in proximity to Burhi Dehing
AQ2	Jaipur T E Colony	27° 19' 5.909" N 95° 26' 40.253" E	Downwind to all the locations at the north eastern corner; crosswind to the locations at north western corner
AQ3	Panisukia Bongaon	27° 15' 21.886" N 95° 22' 26.482" E	Downwind to all the locations at the north eastern corner; crosswind to the locations at north western corner
AQ4	Naohalia	27° 22' 22.850" N 95° 21' 54.540" E	Upwind to the locations at northwestern corner of the Block. Crosswind to the locations at the northeastern corner of the Block.
AQ5	Borhat	27° 9' 0.070" N 95° 22' 14.089" E	Downwind to all the locations at the north eastern corner; crosswind to the locations at north western corner
AQ6	1No Sapkait	27° 9' 22.687" N 95° 18' 58.222" E	Crosswind to the locations at the centre of the Block.
AQ7	Daman Tiniali	27° 12' 14.471" N 95° 10' 22.645" E	Downwind to the locations at northwestern corner of the Block. Crosswind to the locations at the centre of the Block.
AQ8	Ghuronia bhaticchowk	27° 15' 43.975" N 95° 10' 58.900" E	Downwind to the locations at the central portion of the Block. Cross wind to all other locations

Source: ERM Primary Monitoring

C.

Ambient Noise Monitoring Locations

Sl. No	Monitoring Location	Station Number	Geographical Coordinates		Category of Area/Zone
			Latitude	Longitude	
1.	Balijan	NQ1	27°13'49"N	95°20'03"E	Residential
2.	Nawfalla Village	NQ2	27°14'38"N	95°14'51"E	Residential
3.	Dhonekhona Gaon	NQ3	27°07'04"N	95°14'43"E	Residential
4.	Samdar Ghat	NQ4	27°09'01"	95°18'11"E	Residential
5.	Gargorie(Polyalepather School)	NQ5	27°13'23"N	95°14'19"E	Residential
6.	Chamguri Gaon	NQ6	27°13'18"N	95°15'53"E	Residential
7.	Balimora Gaon	NQ7	27°13'22"	95°21'13"E	Residential
8.	Namrup Near rail Station	NQ8	27°11'37"N	95°21'16"E	Residential
9.	Borhat Gaon	NQ9	27°09'46"N	95°15'38"E	Residential
10.	Samdar Gaon	NQ10	27°10'40"N	95°17'43"E	Residential
11.	Borpathar TEA State	NQ11	27°08'54"N	95°20'38"E	Residential
12.	Salakatani	NQ12	27°06'08"E	95°11'42"E	Residential
13.	Mridong Para	NQ13	27°08'27"N	95°12'08"E	Residential
14.	Rohan Pothar	NQ14	27°11'20"N	95°12'49"E	Residential
15.	Medala Jan	NQ15	27°10'54"N	95°19'20"E	Residential
16.	Namrup-1	NQ16	27°12'25"N	95°19'50"E	Residential
17.	Chringklhat	NQ17	27°21'39.6"N	95°17'30.12"E	Residential
18.	Nagajan Gaon	NQ18	27°21'27.7"N	95°28'00.48"E	Residential
19.	Fekerajan gaon	NQ19	27°18'54.72"N	95°27'23.0"E	Residential
20.	Erapathara Gaon	NQ20	27°19'23.52"N	95°25'28.2"E	Residential
21.	Chuppathatu gaon	NQ21	27°18'14.04"N	95°25'36.12"E	Residential
22.	Tarajan Gaon	NQ22	27°16'55.92"N	95°25'48.0"E	Residential
23.	Bokuloni Gaon	NQ23	27°20'31.9"N	95°24'48.6"E	Residential
24.	Giliepung Gaon	NQ24	27°20'33.36"N	95°26'32.64"E	Residential
25.	Naoholiya gaon	NQ25	27°21'37.8"N	95°21'56.9"E	Residential
26.	Mohabirbari	NQ26	27° 22' 36.12"N	95° 24' 52.70"E	Residential
27.	Mohamari gaon	NQ27	27°18'6.12"N	95°17'47.4"E	Residential
28.	Amguri gaon napali basti	NQ28	27°20'16.8"	95°14'36.6"E	Residential
29.	Amguri gaon napali basti	NQ29	27°17'9.6"N	95°23'7.8"E	Residential
30.	Dihing Kemar bagoli para	NQ30	27°21'16.2"N	95°11'54.6"E	Residential

Source: ERM Primary Monitoring

D.

Groundwater Monitoring Locations in the Study Area

Sl No.	Monitoring locations	Station No	Latitude	Longitude	Source
1.	Konwarijan	GW-1	27° 5' 22.228" N	95° 10' 33.295" E	Tubewell
2.	1 no Kopa howa	GW-2	27° 22' 10.788" N	95° 21' 38.155" E	Tubewell
3.	2 no Naohalia	GW-3	27° 13' 41.525" N	95° 22' 1.788" E	Tubewell
4.	Bhadoi Nagar	GW-4	27° 9' 18.240" N	95° 19' 53.587" E	Tubewell
5.	Dulang khermia	GW-5	27° 5' 22.228" N	95° 10' 33.295" E	Tubewell

Source: ERM Primary Monitoring

E. Surface water-monitoring locations

SI No	Location	Station No	Latitude	Longitude
1	Burhi Dehing Upstream	SW 1	27° 3' 12.681" N	95° 10' 7.136" E
2	Burhi Dehing Downstream	SW 2	27° 9' 36.351" N	95° 21' 26.511" E
3	Digboi Nala	SW 3	27° 9' 16.424" N	95° 11' 21.582" E
5	Tipling River	SW 4	27° 15' 51.303" N	95° 24' 16.393" E

Source: ERM Primary Monitoring

ANNEXURE 2

Soil Monitoring Results

Sl No.	PARAMETER	Location	Unit	Soil 1	Soil 2	Soil 3	Soil-4	Soil-5	
				Barpathar	Near Janglu kuruka	Namrup Cha bagicha (Santipur)	Lakhi Pather	Chetia pather	
				Lower Detection Limits	Homestead Plantation	Agriculture land	Tea Garden	Forest	Tea Garden
1	Acidity	mg/kg	-	Nil	nil	Nil	nil	nil	
2	Alkalinity (as CaCO ₃)	mg/kg	<10.0	70	44	70	44	22	
3	Arsenic (as As)	mg/kg	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	
4	Boron (as B)	mg/kg	<0.25	31	24	58	4.2	1.8	
5	Bulk Density	gm/cc	<1.0	1.11	1.18	1.05	1.05	1.03	
6	Cadmium (as Cd)	mg/kg	<2.0	6.2	<2.0	<2.0	<2.0	<2.0	
7	Calcium (as Ca)	mg/kg	<50.0	392	588	588	588	392	
8	Carbonate	mg/kg	-	nil	nil	nil	nil	nil	
9	Cation Exchange Capacity	meq/100 gm	<5.0	11.2	11.6	8.4	14	12	
10	Chloride (as Cl)	mg/kg		29	29	49	49	29	
11	Copper (as Cu)	mg/kg	<2.0	17	8	16	15	22	
12	Electrical conductivity	us/cm	<10.0	192	103	58	78	106	
13	Hexavalent Chromium (as Cr+6)	mg/kg	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
14	Iron (as Fe)	mg/kg	<5.0	112	1088	138	219	1571	
15	Lead (as Pb)	mg/kg	<2.0	10	7	13	12	20	
16	Magnesium (as Mg)	mg/kg	<30.0	176	177	294	412	118	
17	Mercury (as Hg)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
18	Moisture	%	<1.0	20.9	18.9	23.4	32.8	26.6	
19	Nitrogen (as N)	mg/kg	<14.0	226	302	408	444	400	
20	Particle Size Distribution	%	<2.0	sand:24.3 silt:10.1 clay:65.6	sand:14.6 silt:12.5 clay:72.9	sand:20.8 silt:16.4 clay:62.8	sand:21.7 silt:14.8 clay:63.5	sand:27.3 silt:14.5 clay:58.2	
21	Permeability	Cm/hr	<0.04	0.026	0.017	0.048	0.020	0.035	
22	Phosphorus (as P)	mg/kg	<3.0	20	<3.0	<3.0	<3.0	<3.0	
23	Porosity	%	<35.0	48.4	46.8	49.9	52.3	51	

Sl No.	PARAMETER	Location		Soil 1	Soil 2	Soil 3	Soil-4	Soil-5
		Barpathar	Near Janglu kuruka	Namrup Cha bagicha (Santipur)	Lakhi Pather	Chetia pather		
		Unit	Lower Detection Limits	Homestead Plantation	Agriculture land	Tea Garden	Forest	Tea Garden
24	Potassium (as K)	mg/kg	<10.0	581	32	59	34	49
25	Sodium (as Na)	mg/kg	<5.0	30	19	19	39	21
26	Sodium Adsorption Ration (as SAR)	-	-	0.33	0.19	0.16	0.31	0.24
27	Specific gravity	-	-	2.15	2.1	2.04	2.2	2.1
28	Sulphate (as SO ₄)	mg/kg	<15.0	<15	<15	<15	<15	<15
29	Texture	-	-	clay	clay	clay	clay	clay
30	Zinc (as Zn)	mg/kg	<2.0	42	29	58	54	60
31	pH value	-	<3.0	5.69	5.03	5.13	5.38	5.32
32	Infiltration Capacity	mm/Hr	-	2.1	2.7	2.8	2.0	2.9

ANNEXURE 3

Summary of Air Monitoring Data

	PM ₁₀ (µg/m ³)	PM _{2.5} (µg/m ³)	SO ₂ (µg/m ³)	NO ₂ (µg/m ³)	CO (mg/m ³)	Hydrocarbon (ppm)	Hydrocarbon (as Non-Methane) ppm	VOC (µg/m ³)
Chapatali								
Average	63.42	34.17	5.66	17.40	0.30	1.46	-	-
Min	38.00	16.00	4.30	10.20	0.12	0.58	<0.50	<2.08
Max	97.00	57.00	7.80	27.40	0.68	3.20	0.50	-
98 th Percentile	92.40	53.78	7.52	25.51	0.57	2.74	-	-
Jaipur T.E colony								
Average	82.46	45.46	6.20	20.18	0.37	1.03	-	-
Min	52.00	27.00	4.50	12.20	0.22	0.65	<0.50	<2.08
Max	132.00	65.00	7.80	26.80	0.73	1.66	1.99	2.40
98 th Percentile	132.00	65.00	7.66	26.66	0.66	1.49	-	-
Panisukia Bongaon								
Average	80.42	44.38	6.38	20.89	0.47	1.14	-	-
Min	48.00	19.00	4.20	13.30	0.22	0.56	<0.50	<2.08
Max	134.00	67.00	8.60	27.20	0.72	1.96	1.88	2.30
98 th Percentile	128.02	62.86	8.51	26.92	0.71	1.82	-	-
Naohalia								
Average	63.75	34.63	6.00	18.96	0.36	1.60	-	-
Min	38.00	20.00	4.50	10.60	0.14	0.68	-	-
Max	95.00	54.00	8.20	26.60	0.78	2.78	<0.50	<2.08
98 th Percentile	92.70	53.54	7.88	26.55	0.77	2.71	-	-
Borhat								
Average	78.00	43.25	5.77	19.93	0.46	0.96	-	-
Min	27.00	22.00	4.20	12.50	0.16	0.65	-	-
Max	135.00	65.00	8.30	28.70	0.88	1.33	<0.50	<2.08
98 th Percentile	123.96	60.86	8.12	28.29	0.87	1.31	-	-
1No Sapkait								
Average	85.38	45.38	6.12	19.93	0.41	1.03	-	-
Min	45.00	20.00	4.40	12.50	0.15	0.46	<0.50	<2.08
Max	136.00	68.00	7.90	26.90	0.84	1.85	1.88	2.66
98 th Percentile	130.94	66.16	7.85	26.85	0.82	1.80	-	-

	PM ₁₀ (µg/m ³)	PM _{2.5} (µg/m ³)	SO ₂ (µg/m ³)	NO ₂ (µg/m ³)	CO (mg/m ³)	Hydrocarbon (ppm)	Hydrocarbon (as Non-Methane) ppm	VOC (µg/m ³)
Daman Tiniali								
Average	81.38	43.50	6.14	21.73	0.58	1.01	-	-
Min	48.00	19.00	4.60	15.60	0.22	0.52	<0.50	-
Max	130.00	69.00	8.60	28.60	1.06	1.85	1.38	<2.08
98 th Percentile	126.32	67.16	8.37	27.96	1.00	1.75	-	-
Ghuronia Bhatichowk								
Average	79.83	41.96	6.33	20.99	0.56	1.02	-	-
Min	46.00	22.00	4.70	13.30	0.22	0.35	<0.50	-
Max	116.00	66.00	8.30	27.30	0.95	1.65	1.22	<2.08
98 th Percentile	113.24	63.24	8.25	27.12	0.93	1.65	-	-

ANNEXURE 4

Noise Monitoring Results

ANNEXURE 5

Groundwater Monitoring Results

Parameters	Unit	Lower Detecti on Limit	Accept able Limit	Permiss ible Limit	Changme Gaon	Vagyapur	Pathalibam Lahlo	Dihajan	Telaigaon	Banamali
2,4-Dichlorophenoxyacetic acid	µg/l	<0.01	30		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Alachlor	µg/l	<0.02	20		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Aldrin	µg/l	<0.01	0.03		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Alkalinity (as CaCO ₃)	mg/l	<2.0	200	600	87	50	113	83	35	100
Alpha -endosulfan	µg/l	<0.01	0.04		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Alpha-HCH	µg/l	<0.01	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Aluminium (as Al)	mg/l	<0.01	0.03	0.2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ammonia (as total ammonia- N)	mg/l	<0.1	0.5	NR	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Anionic Detergents (as MBAS)	mg/l	<0.02	0.2	1	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Arsenic(as As)	mg/l	<0.005	0.01	0.05	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Atrazine	µg/l	<0.02	2		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Barium (as Ba)	mg/l	<0.05	0.7	NR	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Beta-Endosulfan	µg/l	<0.01	0.04		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Beta-HCH	µg/l	<0.01	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Boron (as B)	mg/l	<0.5	0.3	1.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Bromodichloromethane	mg/l	<0.05	0.6	NR	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Bromoform	mg/l	<0.05	0.1	NR	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Butachlor	µg/l	<0.02	125		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cadmium (as Cd)	mg/l	<0.001	0.003	NR	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Calcium (as Ca)	mg/l	<0.4	75	200	16	11	16	16	9	11
Chloramines (as Cl ₂)	mg/l	<0.3	4	NR	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Chloride (as Cl)	mg/l	<1.0	250	1000	27	59	41	25	18	12

Parameters	Unit	Lower Detection Limit	Acceptable Limit	Permissible Limit	Changme Gaon	Vagyapur	Pathalibam Lahlo	Dihajan	Telaigaon	Banamali
Chloroform	mg/l	<0.05	0.2	NR	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chlorpyrifos	µg/l	<0.02	30		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cobalt (as Co)	mg/l	<0.5			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Colour	Hazen	<1.0	5	25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Copper (as Cu)	mg/l	<0.02	0.05	1.5	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cyanide (as CN)	mg/l	<0.01	0.05	NR	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Delta-HCH	µg/l	<0.01	0.04		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibromochloromethane	mg/l	<0.05	0.1	NR	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dieldrin	µg/l	<0.01	0.3		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
<i>E.coli</i>	/100 ml	Not Detected	Shall not be detectable in 100 ml sample	Shall not be detectable in 100 ml sample	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
Endosulfan sulfate	µg/l	<0.01	0.04		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethion	µg/l	<0.02	3		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Fluoride (as F)	mg/l	<0.1	1	1.5	0.19	0.17	0.37	0.12	<0.1	<0.1
Free Residual Chlorine	mg/l	<0.1	0.2	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Gama-HCH(Lindane)	µg/l	<0.01	2		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Hydrogen Sulphide (as H ₂ S)	mg/l	<0.01	0.05	NR	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron (as Fe)	mg/l	<0.05	0.3	1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Isoproturon	µg/l	<0.02	9		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Lead (as Pb)	mg/l	<0.005	0.01	NR	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Magnesium (as Mg)	mg/l	<0.24	30	100	7.4	8.5	16	9.1	2.0	16
Malathion	µg/l	<0.02	190		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

Parameters	Unit	Lower Detection Limit	Acceptable Limit	Permissible Limit	Changme Gaon	Vagyapur	Pathalibam Lahlo	Dihajan	Telaigaon	Banamali
Manganese (as Mn)	mg/l	<0.02	0.1	0.3	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mercury (as Hg)	mg/l	<0.001	0.001	NR	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Methyl parathion	µg/l	<0.02	0.3		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mineral Oil	mg/l	<0.01	0.01	0.03	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Molybdenum (as Mo)	mg/l				<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Monocrotophos	µg/l	<0.02	1		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel (as Ni)	mg/l				<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrate (as NO ₃)	mg/l	<0.5	45	NR	<0.5	8.6	21	34	26	<0.5
o,p-DDD	µg/l	<0.01	1		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
o,p-DDE	µg/l	<0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
o,p-DDT	µg/l	<0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Odour	-	Qualitative	Agreeable	Agreeable	UNOBJECTIONABLE	UNOBJECTIONABLE	unobjectionable	unobjectionable	UNOBJECTIONABLE	unobjectionable
p,p-DDD	µg/l	<0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
p,p-DDE	µg/l	<0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
p,p-DDT	µg/l	<0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
pH	-	<3.0	6.5-8.5	NR	6.48 at 25 degC	6.79 at 25 degC	6.35 AT 25 DEGc	6.92 at 25 dsegC	6.38 at 25 degC	6.22 AT 25 DEGc
Phenolic Compounds (as C ₆ H ₅ OH)	mg/l	<0.001	0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Phorate	µg/l	<0.02	2		<0.02	<0.02	<0.02	<0.02	<0.01	<0.02
Polychlorinated biphenyls (as PCB)	mg/l	<0.0005	0.0005	NR	<0.0005	<0.0005	<0.0005	<0.0005	<0.005	<0.0005
Polynuclear Aromatic Hydrocarbons (as PAH)	mg/l	<0.0001	0.0001	NR	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Selenium (as Se)	mg/l	<0.005	0.01	NR	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Silver (as Ag)	mg/l	<0.005	0.1	NR	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Sulphate (as SO ₄)	mg/l	<1.0	200	400	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Parameters	Unit	Lower Detecti on Limit	Accept able Limit	Permiss ible Limit	Changme Gaon	Vagyapur	Pathalibam Lahlo	Dihajan	Telaigaon	Banamali
Taste	-	Qualita tive	Agreea ble	Agreeab le	AGREEABLE	AGREEABLE	agreeable	agreeable	AGREEABLE	agreeable
Total Chromium (as Cr)	mg/ l	<0.01	0.05	NR	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total coliform bacteria	/100 ml	Not Detecte d	Shall not be detecta ble in 100 ml sample	Shall not be detectab le in 100 ml sample	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
Total Dissolved Solids (as TDS)	mg/ l	<2.0	500	2000	96	127	172	108	58	120
Total Hardness (as CaCO ₃)	mg/ l	<2.0	200	600	71	63	106	78	31	94
Turbidity	N.T. U.	<1.0	1	5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Zinc (as Zn)	mg/ l	<0.02	5	15	<0.02.	0.08	<0.02	<0.02	<0.02	<0.02

ANNEXURE 6

Surface Water Monitoring Results

SI No	PARAMETER	Location	Lower Detection Limit	Burhi Dihing down River	Burhi Dihing Up	Digboi Nala	Tipling Nala
		Unit		SW-1	SW-2	SW-3	SW-4
1	Arsenic(as As)	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005
2	Biochemical Oxygen Demand (as BOD)	mg/l	<2.0	2.4	<2.0	<2.0	<2.0
3	Boron (as B)	mg/l	<0.5	<0.5	<0.5	<0.5	<0.5
4	Cadmium (as Cd)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
5	Chemical Oxygen Demand (COD)	mg/l	<4.0	18	8	<4.0	<4.0
6	Chloride (as Cl)	mg/l	<1.0	21	6	27	16
7	Copper (as Cu)	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02
8	Dissolved Oxygen	mg/l	<1.0	8	7.9	6.2	6.4
9	Electrical conductivity	µS/cm	<1.0	150	168	195	194
10	Fluoride (as F)	mg/l	<0.1	<0.1	<0.1	0.14	0.25
11	Free Ammonia	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
12	Hexavalent Chromium (as Cr+6)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
13	Iron (as Fe)	mg/l	<0.05	1.8	1.1	2.8	1.4
14	Lead (as Pb)	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005
15	Manganese (as Mn)	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02
16	Mercury (as Hg)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
17	Nickel (as Ni)	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02
18	Nitrate (as NO3)	mg/l	<0.5	<0.5	0.6	<0.5	1.4
19	Oil and Grease	mg/l	<1.4	<1.4	<1.4	<1.4	<1.4
20	Phenol	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
21	Potassium (as K)	mg/l	<0.1	2.8	1.5	3.0	1.3
22	Salinity	In respect to KCl, equivalent salinity 35	-	0.087	0.097	0.111	0.111
23	Sodium (as Na)	mg/l	-	6	5.2	20.7	9.1
24	Sodium Adsorption Ration (as SAR)	-	<2.0	0.39	0.24	1.1	0.62
25	Sulphate (as SO4)	mg/l	<1.0	<1.0	<1.0	<1	<1

SI No	PARAMETER	Location		Burhi Dihing down River	Burhi Dihing Up	Digboi Nala	Tipling Nala
		Unit	Lower Detection Limit	SW-1	SW-2	SW-3	SW-4
26	Temperature	Deg C	-	19	19	21	22
27	Total Alkalinity (as CaCO ₃)	mg/l	<2.0	56	88	74	70
28	Total Hardness (as CaCO ₃)	mg/l	<2.0	44	72	59	71
29	Total Nitrogen (as N)	mg/l	-	2	<0.3	<0.3	0.4
30	Total Phosphorus	mg/l	-	0.79	0.87	<0.05	<0.05
31	Turbidity	N.T.U.	<1.0	27	19	6	2
32	Zinc (as Zn)	mg/l		<0.02	<0.02	<0.02	<0.02
33	pH value	-	<3.0	7.3	7.1	6.42	6.73
34	Total Dissolved Solids (as TDS)	mg/l	<2.0	88	98	128	115
35	Total Suspended Solid (as TSS)	mg/l	-	20	14	<2.5	7.7
36	Faecal coliform	/100ml	Not Detected	Detected	Detected	Detected	Detected
37	Total coliform	MPN/100ml	Not Detected	79	540	49	11

ANNEXURE 7

Primary Traffic Monitoring Results

Dibrugarh-Digboi Road							
SL · N O.	TIME (Hours)	Motorized Vehicles			Non- Motorized Vehicles	Tot al	PC U
		Heavy Motor Vehicles	Light Motor Vehicles	Two/Three Wheelers			
		(Truck, Bus, Dumper, Tanker, Trailer)	(Car, Jeep, Van, Matador, Tractor, Tempo, Mini Bus)	(Scooter, Motor Cycle, Auto, Moped)			
1	9.00- 10.00	78	198	198	87	561	58 7
2	10.00- 11.00	81	208	192	81	562	60 4
3	11.00- 12.00	89	226	182	69	566	64 2
4	12.00- 13.00	93	252	204	64	613	69 2
5	13.00- 14.00	121	287	206	67	681	82 7
6	14.00- 15.00	77	242	237	70	626	64 4
7	15.00- 16.00	91	258	213	76	638	69 8
8	16.00- 17.00	84	240	188	79	591	64 4
9	17.00- 18.00	95	199	183	40	517	63 1
10	18.00- 19.00	73	174	121	46	414	49 9
11	19.00- 20.00	82	166	123	28	399	52 0
12	20.00- 21.00	66	147	93	21	327	42 9
13	21.00- 22.00	72	144	36	6	258	41 5
14	22.00- 23.00	54	120	19	2	195	31 9
15	23.00- 00.00	42	95	20	0	157	25 2
16	00.00- 01.00	23	47	0	0	70	12 8
17	01.00- 02.00	6	0	0	0	6	21
18	02.00- 03.00	9	0	0	0	9	32
19	03.00- 04.00	0	0	0	0	0	0
20	04.00- 05.00	0	0	2	0	2	1
21	05.00- 06.00	0	0	0	0	0	0
22	06.00- 07.00	15	20	6	2	43	76
23	07.00- 08.00	38	38	22	17	115	18 5
24	08.00- 09.00	57	67	34	34	192	29 0
Total Numbers		1346	3128	2279	789	754 2	91 36

Naharkatia-Moran Road							
S L. N O.	TIME (Hours)	Motorized Vehicles			Non- Motorized Vehicles	Total	PCU
		Heavy Motor Vehicles	Light Motor Vehicles	Two/Thre e Wheelers			
		(Truck, Bus, Dumper, Tanker, Trailer)	(Car, Jeep, Van, Matador, Tractor, Tempo, Mini Bus)	(Scooter, Motor Cycle, Auto, Moped)			
1	9.00- 10.00	53	188	96	77	414	437
2	10.00- 11.00	84	216	89	85	474	572
3	11.00- 12.00	83	213	96	59	451	563
4	12.00- 13.00	69	174	132	62	437	494
5	13.00- 14.00	69	158	105	54	386	463
6	14.00- 15.00	64	170	116	61	411	464
7	15.00- 16.00	87	208	157	77	529	606
8	16.00- 17.00	91	227	134	87	539	630
9	17.00- 18.00	73	254	135	97	559	596
10	18.00- 19.00	59	212	130	77	478	499
11	19.00- 20.00	73	215	114	57	459	539
12	20.00- 21.00	90	174	117	39	420	555
13	21.00- 22.00	96	171	64	34	365	546
14	22.00- 23.00	74	160	68	13	315	456
15	23.00- 00.00	44	90	23	0	157	256
16	00.00- 01.00	12	27	12	0	51	75
17	01.00- 02.00	6	24	0	0	30	45
18	02.00- 03.00	12	11	0	0	23	53
19	03.00- 04.00	11	0	0	0	11	39
20	04.00- 05.00	4	0	0	0	4	14
21	05.00- 06.00	2	0	0	2	4	7
22	06.00- 07.00	23	10	6	4	43	94
23	07.00- 08.00	23	44	13	17	97	134
24	08.00- 09.00	55	85	54	37	231	312

ANNEXURE 8

Phytosociological Survey Location

Code	Habitat Type	Latitude (Northing)	Longitude (Easting)
E1	Agricultural	27°20'57.08"N	95°26'19.06"E
E2	Agricultural	27°19'50.16"N	95°23'37.09"E
E3	Agricultural	27°18'39.79"N	95°22'45.91"E
E4	Agricultural	27°17'1.74"N	95°23'41.12"E
E5	Agricultural	27°15'1.98"N	95°18'31.08"E
E6	Agricultural	27°12'49.47"N	95°19'2.14"E
E7	Agricultural	27°11'25.13"N	95°19'26.23"E
E8	Agricultural	27°12'0.35"N	95°15'30.57"E
E9	Bamboo brake	27°16'59.89"N	95°23'40.97"E
E10	Forest	27°20'42.67"N	95°28'46.35"E
E11	Forest	27°20'14.60"N	95°26'59.04"E
E12	Homestead Plantation	27.31653°N	95.43560°E
E13	Homestead Plantation	27°20'15.14"N	95°26'57.74"E
E14	Homestead Plantation	27°18'49.36"N	95°20'9.15"E
E15	Homestead Plantation	27°18'39.92"N	95°22'46.55"E
E16	Homestead Plantation	27°15'25.58"N	95°15'23.82"E
E17	Homestead Plantation	27°14'57.37"N	95°18'28.03"E
E18	Homestead Plantation	27°12'50.48"N	95°19'4.63"E
E19	Homestead Plantation	27°11'27.65"N	95°19'21.78"E
E20	Homestead Plantation	27°14'1.70"N	95°16'10.94"E
E21	Homestead Plantation	27°14'2.64"N	95°16'10.87"E
E22	Homestead Plantation	27°12'1.69"N	95°15'30.43"E
E23	Homestead Plantation	27°13'40.49"N	95°12'25.75"E
E24	Vegetation Patch	27°17'15.71"N	95°23'50.50"E
E25	Riparian	27.34509°N	95.47958°E
E26	Riparian	27°19'50.92"N	95°23'38.29"E
E27	Riparian	27°19'23.86"N	95°21'50.53"E
E28	Riparian	27°11'28.55"N	95°19'23.50"E
E29	Riparian	27°15'1.15"N	95°18'30.22"E
E30	Riparian	27°15'25.56"N	95°15'24.61"E
E31	Tea Plantation	27°16'46.19"N	95°20'32.32"E
E32	Tea Plantation	27°15'24.05"N	95°15'24.62"E
E33	Tea Plantation	27°11'29.56"N	95°19'23.37"E
E34	Tea Plantation	27°20'58.32"N	95°26'14.51"E
E35	Tea Plantation	27°20'27.90"N	95°23'23.88"E
E36	Tea Plantation	27°14'57.78"N	95°18'26.89"E

Source: ERM Primary Monitoring

ANNEXURE 9

List of Plant Species Present in Study Area

Sl. No.	Scientific Name	Common Name
Trees		
1.	<i>Actinodaphne angustifolia</i> (Bl.) Nees	
2.	<i>A. obovata</i> Blume.	Patihonda
3.	<i>A. pedunculosa</i> Wall	
4.	<i>A. undulata</i> Clarke	
5.	<i>A. humilis</i> Vahl.	Tolothapoka
6.	<i>Adina polycephala</i> Benth	
7.	<i>Aegle marmelos</i> (L.) Correa	
8.	<i>Ailanthus grandis</i> Prain	
9.	<i>Alangium chinensie</i> (L) Harms.	Chikamorolia
10.	<i>Albizia chinensis</i>	
11.	<i>Albizia lebeck</i> (L.) Benth.	
12.	<i>Albizia</i> sp.	
13.	<i>Albizzia procera</i> Benth	Boga koro
14.	<i>Aleurites fordii</i> Hemsl	Tang
15.	<i>Alstonia scholaris</i> (L) R Br.	Chotiona
16.	<i>Altingia excelsa</i> Bl.	Jutuli tenga
17.	<i>Aquilaria malaccensis</i> Benth	Sasi
18.	<i>Ardisia depressa</i> Clark	
19.	<i>Areca catechu</i> L.	
20.	<i>Artocarpus chaplasha</i> Roxb.	Cham kothal
21.	<i>Artocarpus heterophyllus</i> Lam.	
22.	<i>Azadirachta indica</i> A. Juss.	
23.	<i>Baccaurea sapida</i> Muell. & Arg	Leteku
24.	<i>Bischofia javanica</i> Blume	
25.	<i>Bombax ceiba</i> L.	
26.	<i>Bridelia pubescens</i> . Kurz	
27.	<i>C. armata</i> Sparh.	
28.	<i>C. ciciodaphane</i> Meissn.	Gondhkoroi
29.	<i>Canarium bengalense</i> Roxb	Dhuna
30.	<i>Caryota urens</i> L.	
31.	<i>Castanopsis indica</i> A.Dc.	Hingori
32.	<i>Cinamomum obtusifolium</i> . Nees	Noga Dalchini
33.	<i>Cocos nucifera</i> L.	
34.	<i>Crypteronia paniculata</i> Bl	
35.	<i>Cryptocarya floribunda</i> . Nees	
36.	<i>D. alliarium</i> (Buch-Hm.) Balakr	Gendheli Poma

Sl. No.	Scientific Name	Common Name
37.	<i>D. procerum</i> Hiern	Lali amari
38.	<i>D. variegata</i> Kurz.	Koliori
39.	<i>Dendrocalamus hamiltonii</i> Nees & Arn	Kako Bah
40.	<i>Dillenia indica</i> L.	
41.	<i>Diospyros lanceaefolia</i> Roxb.	Kendu Gach
42.	<i>Dipterocarpus retusus</i> Bl	Holong
43.	<i>Drimycarpus recemosus</i> (Roxb) Hk.F	Amsia
44.	<i>Duabanga grandiflora</i> (Roxb.ex DC.)Walp	
45.	<i>Dysoxylum binectiferum</i> (Roxb.) Hook. f	Bandardima
46.	<i>Eleocarpus ganitus</i> Roxb	Rudraksha
47.	<i>Eucalyptus</i> sp.	
48.	<i>F. fistulosa</i> Reinw	
49.	<i>F. glaberrima</i> Bl	
50.	<i>Ficus clavata</i> Wall	
51.	<i>Ficus hispida</i> L. fil.	
52.	<i>Ficus religiosa</i> L.	
53.	<i>G. lanceaefolia</i> (Roxb)	Rupohi Thekera
54.	<i>G. xanthochymus</i> Hk.f	Tepor tenga
55.	<i>Garcinia cowa</i> Roxb	Thekera
56.	<i>Gmelina arborea</i> Roxb. ex Sm.	
57.	<i>Helicia excelsa</i> (Roxb.) Bl	
58.	<i>Juglans regia</i> Linn.	Kathbadam
59.	<i>L. elongata</i> Benth and Hook.	Petari chua
60.	<i>L. khasiana</i> Meissn.	
61.	<i>L. laeta</i> Benth &Hook.f	Bonhualu
62.	<i>L. lanuginosa</i> Nees	
63.	<i>L. oblonga</i> (Nees)Hook.f.	
64.	<i>L. reticulata</i> .Benth	
65.	<i>L. sabifera</i> .Pers.	Baghnola
66.	<i>L. thomsonii</i> Hk.f	
67.	<i>Lagerstroemia speciosa</i> (L) Pers.	Ajar
68.	<i>Lannea grandis</i> (Dennst.) Engl.	
69.	<i>Lasianthus tubiferus</i> Hook.f.	
70.	<i>Lindera griffithii</i> Meisn	
71.	<i>Litchi chinensis</i> Sonner.	
72.	<i>Litsea citrata</i> Bl.	Mezankori
73.	<i>Livistona jenkinsiana</i> Griff.	

Sl. No.	Scientific Name	Common Name
74.	<i>M. manii</i> King	Kothal chopra
75.	<i>M. montana</i> A.Dc	NK
76.	<i>M. oblonga</i> Wall ex H.Kf. Thomas.	Ful chopra,
77.	<i>M.philippensis</i> (Lam) Muell &A	Senduri Guti
78.	<i>Maesa indica</i> Wall.	Machpora
79.	<i>Magnolia sphenocarpa</i> Hook.f.& Th	Doloi Chopra
80.	<i>Mallotus alba</i> Muell & Arg.	Morolia gach
81.	<i>Mangifera indica</i> L	Aam
82.	<i>Mangifera sylvatica</i> Roxb.	
83.	<i>Mecaranga denticulatum</i> Muell	
84.	<i>Melia azedarach</i> L.	
85.	<i>Mesua ferrea</i> L.	Nahor
86.	<i>Michelia champaca</i> Linn	Tita chopra
87.	<i>Michelia hodgsonii</i> Hooker f. & T.	Borhmothuri
88.	<i>Millettia cinerea</i> Benth	Bokol Bih
89.	<i>Moringa oleifera</i> Lam.	
90.	<i>Musa</i> sp.	
91.	<i>Myristica longifolia</i> .Wall	
92.	<i>Neolamarckia cadamba</i> (Roxb.) Bosser	
93.	<i>Olea dioica</i> Roxb.	
94.	<i>Ormosia robusta</i> (Weight)	
95.	<i>Oroxylum indicum</i> (L.) Kurz	
96.	<i>P. lanceafolium</i> Roxb	Bon bogori,
97.	<i>Peltophorum pterocarpum</i> (DC.)K.Heyne	
98.	<i>Phoebe lanceolata</i> Nees	Bon chom
99.	<i>Phyllanthus emblica</i> L.	
100.	<i>Polyathea jenkinsii</i> Benth	Titasachi
101.	<i>Pongamia pinnata</i> (L.) Pierre	
102.	<i>Premna bengalensis</i> Clarke	Gohora
103.	<i>Pterospermum chelonides</i> DC.	
104.	<i>Randia griffithii</i> H.K.f	
105.	<i>S.fruticosum</i> Roxb DC.	Kutahi Jamuk
106.	<i>S.roxburghii</i> Wall.	
107.	<i>S.villosa</i> Roxb.	Udal
108.	<i>Sapium baccatum</i> Roxb.	Borkora
109.	<i>Saprosma ternatum</i> H.K.f	
110.	<i>Sepium baccatum</i>	

Sl. No.	Scientific Name	Common Name
111.	<i>Shorea assamica</i> Dyer.	Mekai
112.	<i>Sterculia balanghuas</i> linn.	Hijol
113.	<i>Stereospermum chelonides</i>	
114.	<i>Syzigium cumini</i> (L) Skeel.	Borjamuk
115.	<i>Syzigium reticulatum</i> (wt) Walp.	
116.	<i>Syzygium oblatum</i> (Roxb)	
117.	<i>T. myriocarpa</i> Heruk & Muell.	Holokh
118.	<i>T.chebula</i> Retz.	Hilikha
119.	<i>Talauma pleocarpa</i> King.	Khorokia chopra
120.	<i>Teinostachyum dullooa</i> Gamble.	Dolo Bah
121.	<i>Terminalia bellerica</i> Roxb.	Bhumura guti
122.	<i>Unona longiflora</i> Roxb.	
123.	<i>Vatica lanceaefolia</i> Blume.	Morsal.
124.	<i>Ziziphus funiculosa</i> Ham.	
125.	<i>Ziziphus mauritiana</i> Lam.	
Shrubs		
1.	<i>Allophyllus zeylanicus</i> Linn Var.grandifolia	
2.	<i>Blastus cochinchinensis</i> Lour	Futkola
3.	<i>Boehmeria nivea</i> (L) Gaud.	Riha
4.	<i>Breynia patens</i> Benth	
5.	<i>C. viscosum</i> Vent.	Dhopat tita
6.	<i>Calamus jenkinsiana</i> Griff.	Raidang bet
7.	<i>Calamus tenuis</i>	Jatibet
8.	<i>Callicarpa arborea</i> Roxb.	Bonmola
9.	<i>Callicarpa longifolia</i> Lam.	
10.	<i>Camellia sinensis</i> (L) Kuntze	
11.	<i>Camellia sinensis</i> (L)Kuntze.	Tea
12.	<i>Casearia veraca</i> Roxb.	Bon kecheru
13.	<i>Chasalia curviflora</i> Thw.	
14.	<i>Citrus aurantium</i> Linn.	Jora tenga
15.	<i>Clerodendron colebrookianum</i>	Nefafu
16.	<i>Croton caudatus</i> Geisel.	Lota mahudi
17.	<i>Cryptolepis sinensis</i> (Lour.) Merr.	
18.	<i>E.platifolium</i> (Nees)	
19.	<i>Eranthemum album</i> Nees.	
20.	<i>Euphorbia</i> sp.	
21.	<i>F. rostrata</i> Lamk.	

Sl. No.	Scientific Name	Common Name
22.	<i>Ficus clavata</i> Wall.	Dimoru
23.	<i>Fissistigma wallichii</i> (Hk.f & Th)	
24.	<i>Garcinia cowa</i> Roxb	Thekera
25.	<i>Glochidion zeylanicum</i> A.Juss.	
26.	<i>Goniothalamus sesquipedalis</i> Hk.f & Th.	
27.	<i>Helicia nilgirica</i> Beddome.	
28.	<i>Hibiscus rosa-sinensis</i>	
29.	<i>I. nilgiricaus</i> R.Br.	
30.	<i>I. subsessilis</i> Wall.	
31.	<i>Ixora acuminata</i> Roxb.	
32.	<i>Ixora villosa</i> Roxb.	
33.	<i>L. salicifolia</i> (Roxb)	Dighloti
34.	<i>Laportea crenulata</i> Gaud.	Churat gach
35.	<i>Lasianthus lucidus</i> Blume.	
36.	<i>Leea indica</i> (Burn) Merr.	Kukurathengia
37.	<i>Litsea lancifolia</i> Roxb.	
38.	<i>Livistona jnkensiana</i> Griff.	Tokou goch
39.	<i>M. villosa</i> H.K. F.	
40.	<i>Melastoma malabethricum</i> Linn.	Ronga Phutukola
41.	<i>Mimosa himalayana</i> Gamble.	Kauri kiat
42.	<i>Morinda angustifolia</i> Roxb.	Akalbih
43.	<i>Myrioneuron nutans</i> Wall.	
44.	<i>Nerium indicum</i> Mill.	Korobi
45.	<i>P. curviflora</i> Nees.	Titaful
46.	<i>Pericampylus incanus</i> (Colebr) Meirs.	Garo lota
47.	<i>Phlogacanthus guttatus</i> Nees.	
48.	<i>Phlogacanthus sp</i>	
49.	<i>Phyllanthus glauca</i> Wall.	Kola bahok
50.	<i>Pinanga gracilis</i> (L) Blume.	Ram tamul
51.	<i>Psychotria silhentensis</i> Deb& Gans	
52.	<i>Rauwolfia densiflora</i> Benth.	
53.	<i>Roydsia suaviolense</i> Roxb.	Modhumola
54.	<i>Schizostachyum polymorphm</i> (Munro).	Bajal Banh
55.	<i>Solanum khasianum</i> C.B.C.	Bor vekruri
56.	<i>Spiradiclis cylindrica</i> Wakk.	
57.	<i>Zallacca secunda</i> Griff.	Jengoo pat
58.	<i>Zizyphus Rugosa</i> Lamk.	Bon Bogori

Sl. No.	Scientific Name	Common Name
Herbs		
1.	<i>Acanthus leucostachyus</i> .Wall	
2.	<i>Achyranthes aspera</i>	
3.	<i>Ageratum conyzoids</i>	
4.	<i>Alocasia forniculata</i> (Roxb) Scott.	
5.	<i>Alpinea bracteata</i> Roxb.	
6.	<i>Amaranthus spinosa</i>	
7.	<i>Andropogon aciculatus</i>	
8.	<i>Apostasia nuda</i> Br.	
9.	<i>Aristida fusca</i>	
10.	<i>Arundinella leptochloa</i> (Nees ex Steud.) Hook.f	
11.	<i>Azolla pinnata</i>	
12.	<i>Bambusa balcooa</i>	
13.	<i>Bambusa tulda</i>	
14.	<i>Barleria cristata</i> Lin.	
15.	<i>Begonia roxburghii</i> A Dc.	
16.	<i>Brassica oleracea</i>	
17.	<i>Canscora andrographiodes</i> Griff.	
18.	<i>Centella asiatica</i>	
19.	<i>Chloranthus officinalis</i> Bl.	
20.	<i>Cleome hassleriana</i>	
21.	<i>Codonacanthus pauciflorus</i> Nees.	
22.	<i>Colocasia affinis</i> Schott.	
23.	<i>Colocasia esculenta</i>	
24.	<i>Commelina obliqua</i> .Ham.	
25.	<i>Costus speciosus</i> (Koen) Smith.	
26.	<i>Crotalaria spectabilis</i>	
27.	<i>Curculigo orchioides</i> Gaert.	
28.	<i>Cymbidium flexus</i> Nees.	
29.	<i>Cyperus</i> sp.	
30.	<i>Diplazium esculentum</i>	
31.	<i>Dracaena petiolata</i> Hk.f &T.	
32.	<i>Dryopteris filix-mas</i>	
33.	<i>Duchesnea indica</i>	
34.	<i>Ebermaiena stacerogyne</i> Nees.	
35.	<i>Eichhornia Crassipes</i>	
36.	<i>Elatostema accuminatum</i> Brog.	

Sl. No.	Scientific Name	Common Name
37.	<i>Eupatorium odoratum</i>	
38.	<i>Eupatorium wallichii</i> Dc.	
39.	<i>Evolvulus nummularius</i>	
40.	<i>Globba multiflora</i> Wall.	
41.	<i>Gnaphalium luteo-album</i>	
42.	<i>Hedychium gracile</i> Roxb.	
43.	<i>Hedyotis costata</i> Br.	
44.	<i>Hedyotis glabra</i> R.Br.	
45.	<i>Hemizymnia fusua</i> Rich.	
46.	<i>Homalomena aromatic</i> Schott.	
47.	<i>Hypopolytrum nemorum</i> (vahl) Spreng.	
48.	<i>Ipomoea fistulosa</i>	
49.	<i>Isachne albeus</i>	
50.	<i>Laportea crenulata</i> Gaud.	
51.	<i>Lasia spinosa</i> (L) Thw.	
52.	<i>Leonurus sibiricus</i>	
53.	<i>Leucas asperra</i>	
54.	<i>ludwigia parviflora</i>	
55.	<i>Malocanna bacciferra</i>	
56.	<i>Marsilea minuta</i>	
57.	<i>Mimosa pudica</i>	
58.	<i>Ocimum canum</i>	
59.	<i>Oenanthes javanica</i> (Bt) Dc.	
60.	<i>Oplismenus compositus</i> (L) P. Beauf.	
61.	<i>Pallia subumbellata</i> .C.B.el.	
62.	<i>Panicum brevifolium</i> Roxb.	
63.	<i>Panicum montanum</i> Roxb.	
64.	<i>Peliosanthes violacca</i> Wall.	
65.	<i>Phrynium capitatum</i> Willd.	
66.	<i>Phrynium pubescence</i>	
67.	<i>Pistia stratiotes</i>	
68.	<i>Polygonum chinense</i> L.	
69.	<i>Polygonum serrulatum</i> Lag.	
70.	<i>Pothos cathcarteae</i>	
71.	<i>Pseudostachium polymorphum</i> Munro.	
72.	<i>Ranunculus sceleratus</i>	
73.	<i>Rhopalephora scaberrima</i> (Bl) Faden.	

Sl. No.	Scientific Name	Common Name
74.	<i>Saccharum officinarum</i>	
75.	<i>Sarcopyramis nepalensis</i> Wall.	
76.	<i>Scleria terrestris</i> (L) Fass.	
126.	<i>Scoparia dulcis</i>	
127.	<i>Sida rhombifolia</i>	
128.	<i>Solanum indicum</i>	
129.	<i>Solanum xanthocarpum</i>	
130.	<i>Spilanthes acmella</i>	
131.	<i>Stenochlaena palustris</i>	
132.	<i>Strobilanthus flaccidifolius</i> Nees.	
133.	<i>Thyzenolena maxima</i>	
134.	<i>Xanthium strumarium</i>	
Climbers and Woody Climbers		
1.	<i>Ampelopsis nerrifolia</i> D.Don.	
2.	<i>Ampelopsis rubifolia</i> Planch.	
3.	<i>Cissampelos Pereira</i> Lin.	
4.	<i>Cyclea bicristata</i> (Griff).	
5.	<i>D.glabra</i> Roxb.	
6.	<i>Dalbergia pinnata</i> (Lour) Prain.	
7.	<i>Derris ferruginea</i> Benth.	
8.	<i>Dioscorea bulbifera</i> L	
9.	<i>Enantheum album</i> .Nees.	
10.	<i>Erythralum scandens</i> Bl.	
11.	<i>Ficus villosa</i> Bl.	
12.	<i>Fissistigma wallichii</i> (Hkf) Thm.	
13.	<i>Gnetum scandens</i> Roxb.	
14.	<i>H. parasitica</i> Wall.	
15.	<i>H. vaccinioides</i> Hook.f.	
16.	<i>Hoya longifolia</i> Wall.ex Wight.	
17.	<i>J. attenuatum</i> Roxb	
18.	<i>J. dispersum</i> Wall	
19.	<i>J. lanceolaria</i> Roxb	
20.	<i>J.laurifolium</i> Roxb	
21.	<i>Jesminum anastomosans</i> Wall	
22.	<i>Marsdenia tinctoria</i> Br	
23.	<i>Mikania micrantha</i> H.B&K	
24.	<i>Mimosa himalayana</i> Gamble	

Sl. No.	Scientific Name	Common Name
25.	<i>Modecca trilobata</i> Roxb	
26.	<i>Myrioneuron smilacifolia</i> Wall.	
27.	<i>Myxopyrum smilacifolium</i> .Bl	
28.	<i>Oxymitra fornicata</i> (Roxb.) Hook. f. &	
29.	<i>P. griffithii</i> C.DC.	
30.	<i>P. hymanophyllum</i> Miq.	
31.	<i>P. syvaticum</i> Roxb.	
32.	<i>Pericampylus glaucus</i> (Colebr) Miers	
33.	<i>Piper attenuatum</i> Ham.	
34.	<i>Polygonum chinense</i> . Linn.	
35.	<i>Pothos cathcartii</i> Schott.	
36.	<i>Rapidophora hookari</i> (Scott).	
37.	<i>Rourea caudata</i> Planch.	
38.	<i>Rubus hamiltoni</i> Hk.f.	
39.	<i>S.hernandifolia</i> (Wall) Walp.	
40.	<i>Sabia limoniaceae</i> Wall.	
41.	<i>Smilex lancaefolia</i> Roxb.	
42.	<i>Stemona tuberosa</i> Lour.	
43.	<i>Stephania glandulifera</i> Nees.	
44.	<i>T. grandiflora</i> Roxb.	
45.	<i>Tetracera sarmentosa</i> L.	
46.	<i>Tetrastigma planicaulata</i> Hk.f.	
47.	<i>Thunbergia coccnea</i> Wall.	
48.	<i>V. elongata</i> Wall.	
49.	<i>V. trifolia</i> Linn	
50.	<i>V.lanceolaria</i> Roxb.	
51.	<i>Vitis capriolata</i> .D.Don.	

Source: Bhaskar Rajbonshi, M. Islam, Plant Diversity of Jeypore Reserve Forest, of Upper Assam, North East India, International Journal of Advance Research and Development, 2018, Volume3, Issue2. and Primary Survey

ANNEXURE 10

**Faunal Species reported from Dihing Patkai
Wildlife Sanctuary by Datta (2014)**

Common Name	Scientific name
Amphibians	
Common Tree Frog	<i>Polypedates teraiensis</i>
Two-Striped Pygmy Tree Frog	<i>Chiromantis vittatus</i>
Large Tree Frog	<i>Rhacophorus maximus</i>
Twin-Spotted Tree Frog	<i>Rhacophorus bipunctatus</i>
Ornamented Pygmy Frog	<i>Microhyla ornate</i>
Indian Skipping Frog	<i>Euphlyetis cyanophlyetis</i>
Indian Bull Frog	<i>Hoplobatrachus tigerinus</i>
Assam Forest Frog	<i>Sylvirana leptoglossa</i>
Common Asian Toad	<i>Duttaphrynus melanostictus</i>
Mountain Horned Frog	<i>Xenophrys parva</i>
Reptiles	
Blue Throated Lizard	<i>Ptyctolaemus gularis</i>
Brook's House Gecko	<i>Hemidactylus brookii</i>
Tokay Gecko	<i>Gecko gecko</i>
Jerdon's Forest Lizard	<i>Calotes jerdoni</i>
	<i>Calotes versicolor</i>
	<i>Calotes mystaceus</i>
	<i>Eutropis macularia</i>
Spotted Litter Skink	<i>Sphenomorphus maculatus</i>
Many-Lined Grass Skink	<i>Eutropis multifasciata</i>
Bengal Monitor	<i>Varanus benghalensis</i>
Water Monitor	<i>Varanus salvator</i>
Yellow Monitor	<i>Varanus flavescens</i>
Burmese Python	<i>Python molurus bivittatus</i>
Copper-Headed Trinket Snake	<i>Coelognathus radiate</i>
Indian Rat Snake	<i>Ptyas mucosa</i>
White Barred Kukri Snake	<i>Oligodon albocinctus</i>
Common Wolf Snake	<i>Lycodon aulicus</i>
Green Cat Snake	<i>Boiga cyanea</i>
Red-Necked Keelback	<i>Rhabdophis subminiatus</i>
Mountain Pit Viper	<i>Ovophis monticola</i>
Jerdon's Pit Viper	<i>Protobothrops jerdonii</i>
Banded Krait	<i>Bungarus fasciatus</i>
Monocled Cobra	<i>Naja kaouthia</i>
King Cobra	<i>Ophiophagus Hannah</i>
Narrow Headed Softshell Turtle	<i>Chitra indica</i>
Malayan Soft Shell Turtle	<i>Amyda cartilaginea</i>
Peacock Shell Turtle	<i>Nilssonina hurum</i>
Malayan Turtle	<i>Cuora amboinensis</i>
Assam Roofed Turtle	<i>Batagur sylhetensis</i>
Tricarinate Turtle	<i>Melanochelys tricarinata</i>
Mammals	
Tiger	<i>Panther tigris</i>
Leopard	<i>Panther pardus</i>

Common Name	Scientific name
Clouded Leopard	<i>Neofelis nelrelosa</i>
Golden Cat	<i>Felis temmincki</i>
Jungle Cat	<i>Felis chaus</i>
Leopard Cat	<i>Felis benghalensis</i>
Fishing Cat	<i>Felis viverrina</i>
Marbled Cat	<i>Felis marmorata</i>
Hoolock Gibbon	<i>Hoolock hoolock</i>
Slow Loris	<i>Nycitrelres coucang</i>
Capped Langur	<i>Trachypithecus pileatus</i>
Assamese Macaque	<i>Macaca assamensis</i>
Rhesus Macaque	<i>Macaca mulatta</i>
Pig-Tailed Macaque	<i>Macaca aretoides</i>
Stamp-Tailed Macaque	<i>Macaca aretoides</i>
Elephant	<i>Elephas maximus</i>
Gaur	<i>Bos quarus</i>
Barking Deer	<i>Muntiacus muntjak</i>
Sambar	<i>Cervus unicolor</i>
Hog Deer	<i>Axix porcinus</i>
Sloth Bear	<i>Melursus urrinus</i>
Binturong	<i>Artictis binturung</i>
Himalayan Black Bear	<i>Selenarcots thibetaurs</i>
Indian Hare	<i>Lepus nigricolis</i>
Indian Porcupine	<i>Hystrix india</i>
Indian Pangolin	<i>Manis crassicaudate</i>
Common Grey Mongoose	<i>Manisedwardsi</i>
Large Indian Civet	<i>Viverra zibetha</i>
Small Indian Civet	<i>Viverricula indica</i>
Common Plan Civet	<i>Paradourus hermapharaditus</i>
Spotted Linsang	<i>Prionodon pardicolor</i>
Malayan Giant Squirrel	<i>Ratufa bicalor</i>
Particoloured Flying Squirrel	<i>Hylopetes alboniger</i>
Wild Boar	<i>Sus scrofa</i>

ANNEXURE 11

Herpetofauna Reported in the Study Area

Family	Species	IUCN category
Gekkonidae	<i>Hemidactylus frenatus</i>	LC
	<i>Hemidactylus brookii</i>	NA
	<i>Hemidactylus garnotii</i>	NA
	<i>Hemidactylus platyurus</i>	NA
	<i>Cyrtodactylus khasiensis</i>	NA
	<i>Gekko gecko</i>	NA
Agamidae	<i>Calotes versicolor</i>	NA
	<i>Ptyctolaemus gulariis</i>	NA
	<i>Draco norvillii</i>	NA
Scincidae	<i>Lygosoma albopunctata</i>	NA
	<i>Sphenomorphus maculatus</i>	NA
	<i>Sphenomorphus indicus</i>	NA
	<i>Eutropis macularia</i>	NA
	<i>Eutropis multifasciata</i>	NA
Lacertidae	<i>Takydromus khasiensis</i>	NA
Varanidae	<i>Varanus bengalensis</i>	LC
	<i>Varanus salvator</i>	LC
	<i>Varanus flavescence</i>	NA
Typhlopidae	<i>Typhlops diardii</i>	LC
Pythonidae	<i>Python bivittatus</i>	VU
Colubridae	<i>Ahaetulla prasina</i>	LC
	<i>Amphiesma stolatum</i>	NA
	<i>Boiga siamensis</i>	NA
	<i>Boiga gokool</i>	NA
	<i>Coelognathus radiatus</i>	LC
	<i>Dendrelaphis cyanochloris</i>	LC
	<i>Dendrelaphis gorei</i>	LC
	<i>Dendrelaphis pictus</i>	NA
	<i>Dinodon septentrionalis</i>	NA
	<i>Lycodon aulicus</i>	NA
	<i>Lycodon jara</i>	LC
	<i>Lycodon zawi</i>	LC
	<i>Oligodon albocinctus</i>	NA
	<i>Oligodon dorsalis</i>	NA
	<i>Oligodon erythrorhachis</i>	DD
	<i>Oligodon cinereus</i>	LC
	<i>Oreocryptophis porphyroacea</i>	NA
	<i>Pareas monticolus</i>	NA
	<i>Psammodynastes pulverulentus</i>	NA
	<i>Ptyas korros</i>	NA
	<i>Ptyas mucosa</i>	NA
<i>Rhabdophis himalayanus</i>	NA	
<i>Rhabdophis subminiatus</i>	LC	
<i>Rhabdophis prasinum</i>	NA	
<i>Xenochropis piscator</i>	NA	

Family	Species	IUCN category
	<i>Xenochropis sp.</i>	
Elapidae	<i>Bungarus fasciatus</i>	LC
	<i>Bungarus niger</i>	NA
	<i>Naja kaouthia</i>	LC
	<i>Ophiophagus Hannah</i>	VU
	<i>Sinomicrurus macclellandi</i>	NA
Viperidae	<i>Ovophis monticola</i>	LC
	<i>Cryptolytrops albolabris</i>	NA
Geoemydidae	<i>Cuora mouhotii</i>	EN
	<i>Cyclemys gemeli</i>	NA
	<i>Pangshura sylhetensis</i>	EN
Trionychidae	<i>Nilssonia hurum</i>	VU
Bufo	<i>Duttaphrynus melanostictus</i>	LC
Megophryidae	<i>Leptobrachium smithi</i>	LC
Microhylidae	<i>Microhyla ornate</i>	NA
Dicroglossidae	<i>Euphlyctis cyanophlyctis</i>	LC
	<i>Hoplobatrachus tigerinus</i>	LC
	<i>Fejervarya pierrei</i>	LC
	<i>Fejervarya limnocharis</i>	LC
	<i>Occidozyga sp.</i>	
Ranidae	<i>Amolops sp.</i>	
	<i>Humerana humeralis</i>	LC
	<i>Odorrana chloronata</i>	NA
	<i>Sylvirana leptoglossa</i>	NA
Rhacophoridae	<i>Chiromantis vittatus</i>	LC
	<i>Polypedates teraiensis</i>	LC
	<i>Polypedates megacephalus</i>	LC
	<i>Rhacophorus suffry</i>	LC
	<i>Rhacophorus maximus</i>	LC
	<i>Rhacophorus bipunctatus</i>	LC
	<i>Theloderma sp.</i>	
	<i>Philautus sp.</i>	
Ichthyophiidae	<i>Ichthyophis sp.</i>	
Chikilidae	<i>Chikila sp.</i>	

Source: Mazedul Islam and Prasanta Kumar Saikia. A study on the road-kill herpetofauna of Jeypore Reserve Forest, Assam NeBIO I An international journal of environment and biodiversity Vol. 5, No. 1, February 2014, 78-83

LC- Least Concern; NA-Not Assessed

ANNEXURE 12

Avifauna Reported in the Study Area

Sl. No.	Common name	Scientific name	IUCN Status
<i>Phasianidae</i>			
1	Red Jungle Fowl	<i>Gallus gallus</i>	LC
2	White-cheeked Partridge	<i>Arborophila atrogularis</i>	NT
3	Rufous-throated Partridge	<i>Arborophila rufogularis</i>	LC
4	Kaleej Pheasant	<i>Lophura leucomelanos</i>	LC
5	Grey Peacock Pheasant	<i>Polyplectron bicalcaratum</i>	LC
6	Barred Buttonquail	<i>Turnix suscitator</i>	LC
7	Small Buttonquail	<i>Turnix sylvatica</i>	LC
8	Blue-breasted Quail	<i>Coturnix chinensis</i>	NA
9	Black Francolin	<i>Francolinus francolinus</i>	LC
10	Swamp Francolin	<i>Francolinus gularis</i>	VU
<i>Anatidae</i>			
11	Ruddy Shelduck	<i>Tadorna ferruginea</i>	LC
12	White-wing Wood Duck	<i>Cairina scutulata</i>	(EN)
13	Lesser Whistling Teal	<i>Dendrocygna javanica</i>	LC
<i>Ciconnidae</i>			
14	Openbill stork	<i>Anastomus oscitans</i>	LC
15	Lesser Adjutant Stork	<i>Leptoptilos javanicus</i>	(VU)
<i>Ardeidae</i>			
16	Cattle Egret	<i>Bulbulcus ibis</i>	LC
17	Little Egret	<i>Egretta garzetta</i>	LC
18	Large Egret	<i>Casmerodius albus</i>	LC
19	Little Heron	<i>Butorides striatus</i>	LC
20	Indian Pond Heron	<i>Ardeola grayii</i>	LC
21	Cinnamon Bittern	<i>Ixobrychus cinnamomeus</i>	LC
22	Yellow Bittern	<i>Ixobrychus sinensis</i>	LC
<i>Phalacrocoracidae</i>			
23	Indian Cormorant	<i>Phalacrocorax fuscicollis</i>	LC
24	Great Cormorant	<i>Phalacrocorax carbo</i>	LC
25	Little Cormorant	<i>Microcarbo niger</i>	LC
<i>Anhingidae</i>			
26	Oriental Darter	<i>Anhinga melanogaster</i>	NT
<i>Accipitridae</i>			
27	Crested Serpent Eagle	<i>Spilornis cheela</i>	LC
28	Eurasian Sparrowhawk	<i>Accipiter nisus</i>	LC
29	Crested Goshawk	<i>Accipiter trivirgatus</i>	LC
30	Pied Harrier	<i>Circus melanoleucos</i>	LC
31	Black Kite	<i>Milvus migrans</i>	LC
32	Shikra	<i>Accipiter badius</i>	LC
33	Long-billed Vulture	<i>Gyps indicus</i>	(CR)
34	Indian White-backed Vulture	<i>Gyps bengalensis</i>	CR
35	Greater Grey-headed Fish-Eagle	<i>Ichthyophaga ichthyaetus</i>	NA
<i>Falconidae</i>			
36	Common Kestrel	<i>Falco tinnunculus</i>	LC
<i>Rallidae</i>			
37	White-breasted Waterhen	<i>Amaurornis phoenicurus</i>	LC
38	Water Cock	<i>Gallicrex cinerea</i>	LC
39	Purple Moorhen	<i>Porphyrio porphyrio</i>	LC
40	Common Moorhen	<i>Gallinula chloropus</i>	LC
<i>Charadriidae</i>			
41	Little-ring Plover	<i>Charadrius dubius</i>	LC
42	Lesser Sand Plover	<i>Charadrius mongolus</i>	LC
43	Little Stint	<i>Calidris minuta</i>	LC
44	Red-wattled Lapwing	<i>Vanellus indicus</i>	LC

Sl. No.	Common name	Scientific name	IUCN Status
45	River Lapwing <i>Scolopacidae</i>	<i>Vanellus duvaucelii</i>	NT
46	Common Snipe	<i>Gallinago gallinago</i>	LC
47	Pintail Snipe	<i>Gallinago stenura</i>	LC
48	Common Greenshank	<i>Tringa nebularia</i>	LC
49	Common Sandpiper <i>Laridae</i>	<i>Actitis hypoleucos</i>	LC
50	River Tern <i>Columbidae</i>	<i>Sterna aurantia</i>	NT
51	Pompadour Green Pigeon	<i>Treron pompadoura</i>	NA
52	Yellow-footed Green Pigeon	<i>Treron phoenicoptera</i>	LC
53	Thick-billed Green Pigeon	<i>Treron curvirostra</i>	LC
54	Pin-tailed Green Pigeon	<i>Treron apicauda</i>	LC
55	Wedge-tailed Green Pigeon	<i>Treron sphenura</i>	LC
56	Green Imperial Pigeon	<i>Ducula aenea</i>	LC
57	Mountain Imperial Pigeon	<i>Ducula badia</i>	LC
58	Purple Wood Pigeon	<i>Columba punicea</i>	VU
59	Ashy Wood Pigeon	<i>Columba pulchricollis</i>	LC
60	Spotted Dove	<i>Streptopelia chinensis</i>	NA
61	Oriental Turtle Dove	<i>Streptopelia orientalis</i>	LC
62	Red Collared Dove	<i>Streptopelia tranquebarica</i>	LC
63	Emerald Dove	<i>Chalcophaps indica</i>	LC
64	Eurasian Collard Dove	<i>Streptopelia decaocto</i>	LC
65	Barred Cuckoo Dove <i>Psittacidae</i>	<i>Macropygia unchall</i>	LC
66	Rose-ringed Parakeet	<i>Psittacula krameri</i>	LC
67	Alexandrine Parakeet	<i>Psittacula eupatria</i>	NT
68	Red-breasted Parakeet	<i>Psittacula alexandri</i>	NT
69	Blossom-headed Parakeet <i>Cuculidae</i>	<i>Psittacula roseata</i>	NT
70	Drongo Cuckoo	<i>Surniculus lugubris</i>	LC
71	Large Hawk Cuckoo	<i>Heirococyx sparverioides</i>	NA
72	Common Hawk Cuckoo	<i>Heirococyx varius</i>	NA
73	Indian Cuckoo	<i>Cuculus micropterus</i>	LC
74	Rufous-bellied Plaintive Cuckoo	<i>Cacomantis merulinus</i>	LC
75	Pied Crested Cuckoo	<i>Clamator jacobinus</i>	LC
76	Red-winged Crested Cuckoo	<i>Clamator coromandus</i>	LC
77	Asian Koel	<i>Eudynamys scolopacea</i>	LC
78	Green-billed Malkoha	<i>Phaenicophaeus tristis</i>	LC
79	Lesser Coucal	<i>Centropus bengalesis</i>	NA
80	Greater Coucal <i>Strigidae</i>	<i>Centropus sinensis</i>	LC
81	Spotted Owlet	<i>Athene brama</i>	LC
82	Collared Owlet	<i>Glaucidium brodiei</i>	LC
83	Asian Barred Owlet	<i>Glaucidium cuculoides</i>	LC
84	Brown Fish Owl	<i>Ketupa zeylonensis</i>	LC
85	Spotted Scops Owl <i>Caprimulgidae</i>	<i>Otus spilocephalus</i>	LC
86	Grey Nightjar <i>Apodidae</i>	<i>Caprimulgus indicus</i>	LC
87	Asian Palm Swift	<i>Cypsiurus balasiensis</i>	LC
88	Himalayan Swiftlet	<i>Collocalia fuciphaga</i>	NA
89	House Swift <i>Trogonidae</i>	<i>Apus affinis</i>	LC

Sl. No.	Common name	Scientific name	IUCN Status
90	Red-headed Trogon <i>Coraciidae</i>	<i>Herpactes erythrocephalus</i>	NA
91	Indian Roller	<i>Coracias benghalensis</i>	LC
92	Oriental Broad-billed Roller <i>Alcedinidae</i>	<i>Eurystomus orientalis</i>	LC
93	White-breasted Kingfisher	<i>Halcyon smyrensis</i>	NA
94	Common Kingfisher	<i>Alcedo atthis</i>	LC
95	Crested Kingfisher	<i>Magaceryle lugubris</i>	NA
96	Ruddy Kingfisher	<i>Halcyon coromanda</i>	NA
97	Oriental Dwarf Kingfisher	<i>Ceyx erithacus</i>	NA
98	Pied Kingfisher	<i>Ceryle rudis</i>	LC
99	Blue-eared Kingfisher	<i>Alcedo meninting</i>	LC
100	Stork-billed Kingfisher <i>Meropidae</i>	<i>Halcyon capansis</i>	NA
101	Green Bee-eater	<i>Merops orientalis</i>	LC
102	Blue-bearded Bee-eater <i>Upupidae</i>	<i>Nyctjornis athertoni</i>	LC
103	Hoopoe <i>Bucerotidae</i>	<i>Upupa epops</i>	LC
104	Oriental Pied Hornbill	<i>Anthracoceros albrostris</i>	NA
105	Brown Hornbill	<i>Anorrhinus tickelli</i>	(NT)
106	Wreathed Hornbill	<i>Aceros undulatus</i>	LC
107	Great Pied Hornbill <i>Megalaimidae</i>	<i>Buceros bicornis</i>	(NT)
108	Coppersmith Barbet	<i>Megalaima haemocephala</i>	NA
109	Blue-throated Barbet	<i>Megalaima asiatica</i>	NA
110	Lineated Barbet	<i>Megalaima lineata</i>	LC
111	Great Barbet	<i>Megalaima virens</i>	LC
112	Golden-throated Barbet <i>Picidae</i>	<i>Megalaima franklinii</i>	NA
113	Fulvous-breasted Woodpecker	<i>Dendrocopos macei</i>	LC
114	Grey-headed Woodpecker	<i>Picus canus</i>	LC
115	Greater Yellownape Woodpecker	<i>Picus flavinucha</i>	LC
116	Lesser Yelloenape Woodpecker	<i>Picus chlorolophus</i>	LC
117	Rufous Woodpecker	<i>Micropternus brachyurus</i>	LC
118	Bay Woodpecker	<i>Blythipicus pyrrhotis</i>	LC
119	Himalayan Flameback	<i>Dinopium shorii</i>	LC
120	Greater Flameback	<i>Chrysocolaptes lucidus</i>	LC
121	Pale-headed Woodpecker	<i>Gecinulus grantia</i>	LC
122	Crimson-breasted Woodpecker	<i>Dendrocopos cathpharius</i>	NA
123	White-browed Piculet	<i>Sasia ochracea</i>	LC
124	Speckled Piculet <i>Pittidae</i>	<i>Picumnus innominatus</i>	LC
125	Blue Pitta	<i>Pita cyanea</i>	NA
126	Blue-naped Pitta <i>Aegithinidae</i>	<i>Pitta nipalensis</i>	LC
127	Common Lora <i>Campephagidae</i>	<i>Aegithina tiphia</i>	LC
128	Rosy Minivet	<i>Pericrocotus roseus</i>	LC
129	Scarlet Minivet	<i>Pericrocotus flammeus</i>	LC
130	Grey-chinned Minivet	<i>Pericrocotus solaris</i>	LC

Sl. No.	Common name	Scientific name	IUCN Status
131	Long-tailed Minivet	<i>Pericrocotus ethologus</i>	LC
132	Large Cuckoo-shrike	<i>Coracina macei</i>	LC
133	Black-winged Cuckoo-shrike	<i>Coracina melaschistos</i>	LC
134	Large Wood-shrike	<i>Tephrodornis gularis</i>	NA
135	Pied Flycatcher-shrike	<i>Hemipus picatus</i>	LC
	<i>Lanidae</i>		
136	Brown Shrike	<i>Lanius cristatus</i>	LC
137	Grey-backed Shrike	<i>Lanius tephronotus</i>	LC
	<i>Monarchidae</i>		
138	Asian Paradise Flycatcher	<i>Terpsiphone paradisi</i>	LC
	<i>Motacillidae</i>		
139	White Wagtail	<i>Motacilla alba</i>	LC
140	Grey Wagtail	<i>Motacilla cinerea</i>	LC
141	Citrine Wagtail	<i>Motacilla citreola</i>	LC
142	Paddyfield Pipit	<i>Anthus rufulus</i>	LC
	<i>Paridae</i>		
143	Great Tit	<i>Parus major</i>	LC
144	Sultan Tit	<i>Melanochlora sultanea</i>	LC
145	Green-backed Tit	<i>Parus monticolus</i>	LC
	<i>Timaliidae</i>		
146	Striated Marsh-Warbler	<i>Megalurus palustris</i>	LC
147	Abott's babbler	<i>Malacocinda abbotti</i>	NA
148	Rufous-capped Babbler	<i>Stachyris ruficeps</i>	LC
149	Golden Babbler	<i>Stachyris chrysaea</i>	LC
150	Spot-throated Babbler	<i>Pnoepyga albiventris</i>	NA
151	Pygmy Wren Babbler	<i>Pnoepyga pusilla</i>	LC
152	Chestnut-capped Babbler	<i>Timalia pileata</i>	LC
153	White-browed Scimitar Babbler	<i>Pomatorhinus schisticeps</i>	LC
154	Streak-breasted Scimitar Babbler	<i>Pomatorhinus ruficollis</i>	LC
155	Wedge-billed Wren Babbler	<i>Sphenocichla humei</i>	(NT)
156	Marsh Babbler	<i>Pellorneum palustre</i>	VU
157	Striped Tit Babbler	<i>Macronous gularis</i>	LC
158	Yellow-eyed Babbler	<i>Chrysomma sinense</i>	LC
159	Striated Babbler	<i>Turdoides earlei</i>	LC
160	Slender-billed babbler	<i>Turdoides longitrostris</i>	NA
161	Jungle Babbler	<i>Turdoides striatus</i>	NA
162	Silver-eared Mesia	<i>Leiothrix argentauris</i>	LC
163	White-crested Laughing Thrush	<i>Garrulax leucolophus</i>	LC
164	White-throated Laughing thrush	<i>Garrulax albogularis</i>	LC
165	Greater-necklace Laughing Thrush	<i>Garrulax pectoralis</i>	LC
166	Lesser-necklace Laughing Thrush	<i>Garrulax monileger</i>	LC
167	Striated Laughing Thrush	<i>Garrulax striatus</i>	LC
168	Rufous-vented Laughing Thrush	<i>Garrulax gularis</i>	LC
169	Rufous-necked Laughing Thrush	<i>Garrulax ruficollis</i>	LC
170	Blue Rock-Thrush	<i>Monticola solitarius</i>	LC
171	Red Faced Liocichla	<i>Liocichla phoenicea</i>	LC
172	White-naped Yuhina	<i>Yuhina bakeri</i>	En

Sl. No.	Common name	Scientific name	IUCN Status
173	White-bellied Yuhina	<i>Yuhina zantholeuca</i>	LC
174	Black-chinned Yuhina	<i>Yuhina nigrimenta</i>	LC
175	Whiskered Yuhina	<i>Yuhina flavicollis</i>	LC
176	Nepal Fulvetta	<i>Alcippe nipalensis</i>	LC
177	Long-tailed Sibia	<i>Heterophasia picaodes</i>	NA
178	Beautiful Sibia	<i>Heterophasia pulchella</i>	LC
179	Cutia	<i>Cutia nipalensis</i>	LC
180	Common Tailorbird	<i>Orthotomus sutorius</i>	LC
181	Mountain Tailorbird	<i>Orthotomus cuculatus</i>	LC
	<i>Phyllocopidae</i>		
182	Grey-cheeked Warbler	<i>Seicercus poliogenys</i>	LC
183	Grey-hooded Warbler	<i>Seicercus xanthoschistos</i>	LC
184	Greenish Warbler	<i>Phylloscopus trochiloides</i>	LC
	<i>Cettidae</i>		
185	Black-faced Warbler	<i>Abroscopus schisticeps</i>	LC
186	Rufous-faced Warbler	<i>Abroscopus albogularis</i>	LC
187	Grey-sided Bush-warbler	<i>Cettia brunnifrons</i>	LC
188	Aberrant-bush warbler	<i>Cettia flavolivacea</i>	NA
	<i>Muscicapidae</i>		
189	Grey-headed Canary-flycatcher	<i>Culicicapa ceylonensis</i>	LC
190	Pale Blue-flycatcher	<i>Muscicapa unicolor</i>	NA
191	Little Pied-flycatcher	<i>Ficedula westermanni</i>	LC
192	White Gorgeted-flycatcher	<i>Ficedula monileger</i>	LC
193	Sapphire Flycatcher	<i>Ficedula sapphira</i>	LC
194	Rufous Gorgeted-flycatcher	<i>Ficedula strophiate</i>	LC
195	Snowy Browed-flycatcher	<i>Ficedula hyperythra</i>	LC
196	Pygmy Blue-flycatcher	<i>Muscicapella hodgsoni</i>	LC
197	Magpie Robin	<i>Copsychus saularis</i>	LC
198	Common Stonechat	<i>Saxicola torquata</i>	LC
199	Grey Bushchat	<i>Saxicola ferrea</i>	LC
200	White-rumped Shama	<i>Copsychus malabaricus</i>	NA
201	Rufous-breasted Bush Robin	<i>Tarsiger indicus</i>	LC
202	White-crowned Forktail	<i>Enicurus leschenaulti</i>	LC
203	Black-backed Forktail	<i>Enicurus immaculatus</i>	LC
204	Slaty-backed Forktail	<i>Enicurus schistaceus</i>	LC
205	Small Niltava	<i>Niltava macgrigoriae</i>	LC
206	Green Cochoa	<i>Cochoa viridis</i>	LC
207	White-capped Water-redstart	<i>Chaimarrornis leucocephalus</i>	LC
208	Daurian Redstart	<i>Phoenicurus aureus</i>	LC
209	Plumbeous Water-redstart	<i>Rhyacornis fuliginosus</i>	LC
	<i>Cisticolidae</i>		
210	Grey-breasted Prinia	<i>Prinia hodgsonii</i>	LC
211	Striated Prinia	<i>Prinia criniger</i>	LC
212	Beavan's Prinia	<i>Prinia rufescens</i>	LC
	<i>Turdidae</i>		
213	Blue Whistling Thrush	<i>Myophonus caeruleus</i>	LC
214	Orange headed Thrush	<i>Geokichla citrina</i>	LC
215	Scaly Thrush	<i>Zoothera dauma</i>	LC
	<i>Chloropseidae</i>		
216	Blue-winged Leafbird	<i>Chloropsis cochinchinensis</i>	NT
217	Golden-fronted Leafbird	<i>Chloropsis aurifrons</i>	LC
218	Asian Fairy-bluebird	<i>Irena puella</i>	LC
	<i>Pycnonotidae</i>		
219	Red-vented Bulbul	<i>Pycnonotus cafer</i>	LC

Sl. No.	Common name	Scientific name	IUCN Status
220	Red-whiskered Bulbul	<i>Pycnonotus jocosus</i>	LC
221	White-throated Bulbul	<i>Alophoixus flaveolus</i>	LC
222	Ashy Bulbul	<i>Hemixos flava</i>	NA
223	Himalayan Bulbul	<i>Pycnonotus leucogenys</i>	LC
224	Striated Bulbul	<i>Pycnonotus striatus</i>	LC
225	Black Bulbul	<i>Hypsipetes leucocephalus</i>	LC
226	Black-crested Bulbul	<i>Pycnonotus melanicterus</i>	LC
227	Mountain Bulbul	<i>Hypsipetes mccllellandii</i>	LC
228	Crested Finchbill	<i>Spizixos canifrons</i>	LC
	<i>Sittidae</i>		
229	Velvet-fronted Nuthatch	<i>Sitta frontalis</i>	LC
230	Chestnut-bellied Nuthatch	<i>Sitta castanea</i>	LC
	<i>Saturnidae</i>		
231	Common Myna	<i>Acridotheres tristis</i>	LC
232	Pied Myna	<i>Sturnus contra</i>	NA
233	Jungle Myna	<i>Acridotheres fuscus</i>	LC
234	Grey-headed Myna	<i>Sturnus malabaricus</i>	LC
235	Hill Myna	<i>Gracula religiosa</i>	LC
	<i>Oriolidae</i>		
236	Black-headed oriole	<i>Oriolus xanthornus</i>	LC
237	Maroon Oriole	<i>Oriolus traillii</i>	LC
	<i>Dicruridae</i>		
238	Black Drongo	<i>Dicrurus macrocercus</i>	LC
239	Bronze Drongo	<i>Dicrurus aeneus</i>	LC
240	Spangled Drongo	<i>Dicrurus hottentottus</i>	LC
241	Ashy Drongo	<i>Dicrurus leucophaeus</i>	LC
242	Lesser Racket-tailed Drongo	<i>Dicrurus remifer</i>	LC
243	Greater Racket-tailed Drongo	<i>Dicrurus paradiseus</i>	LC
	<i>Corvidae</i>		
244	Rufous Treepie	<i>Dendrocitta vagabunda</i>	LC
245	Grey Treepie	<i>Dendrocitta formosae</i>	LC
246	Collared Treepie	<i>Dendrocitta frontalis</i>	LC
247	Common Green Magpie	<i>Cissa chinensis</i>	LC
248	Jungle Crow	<i>Corvus macrorhynchus</i>	NA
249	Common Crow	<i>Corvus splendens</i>	LC
250	White-throated Fantail	<i>Rhipidura albicollis</i>	LC
251	Eurasian Jay	<i>Garrulus glandarius</i>	LC
	<i>Passeridae</i>		
252	House Sparrow	<i>Passer domesticus</i>	LC
	<i>Ploceidae</i>		
253	Baya Weaver	<i>Ploceus philippinus</i>	LC
	<i>Zosteropidae</i>		
254	Oriental white-eye	<i>Zosterops palpebrosus</i>	LC
	<i>Estrildidae</i>		
255	Scaly-breasted Munia	<i>Lonchura punctulata</i>	LC
256	White-rumped Munia	<i>Lonchura striata</i>	LC
257	Black-headed Munia	<i>Lonchura malacca</i>	LC
	<i>Tichodromidae</i>		
258	Wallcreeper	<i>Tichodroma muraria</i>	LC
	<i>Dicacidae</i>		
259	Fire-breasted Flowerpecker	<i>Dicaeum ignipectus</i>	LC
260	Scarlet-backed Flowerpecker	<i>Dicaeum cruentatum</i>	LC
	<i>Nectariniidae</i>		
261	Purple-rumped sunbird	<i>Nectarinia zeylonica</i>	LC
262	Purple Sunbird	<i>Nectarinia asiatica</i>	LC

Sl. No.	Common name	Scientific name	IUCN Status
263	Crimson sunbird	<i>Aethopyga siparaja</i>	LC
264	Green-tailed Sunbird	<i>Aethopyga nipalensis</i>	LC
265	Ruby-cheeked Sunbird	<i>Anthreptes singalensis</i>	LC
266	Fire-tailed Sunbird	<i>Aethopyga ignicauda</i>	LC
267	Streaked Spiderhunter	<i>Arachnothera magna</i>	LC
268	Little Spiderhunter	<i>Arachnothera longirostra</i>	LC
	<i>Aegithalidae</i>		
269	Black-throated Bushtit	<i>Aegithalos concinnus</i>	LC
	<i>Hirundinidae</i>		
270	Common Swallow	<i>Hirundo rustica</i>	LC

Source: Saikia PK, Devi OS. 2011. A checklist of avian fauna at Jeypore Reserve Forest, eastern Assam, India with special reference to globally threatened and endemic species in the Eastern Himalayan biodiversity hotspot. *J Threatened Taxa* 3 (4): 1711-1718.

LC- Least Concern; NA-Not Assessed

ANNEXURE 13

List of Mammals Reported

SI No.	Common Name	Scientific Name
1.	Chinese pangolin	<i>Manis pentadactyla</i>
2.	Himalayan Mole, Indian Short-tailed Mole, Eastern mole	<i>Talpa micrura</i>
3.	House shrew, Grey Musk Shrew	<i>Suncus murinus</i>
4.	Indian Flying Fox	<i>Pteropus giganteus</i>
5.	Bengal slow loris	<i>Nycticebus bengalensis</i>
6.	Nothorn pig-tailed macaque	<i>Macaca leonina</i>
7.	Assamese macaque	<i>Macaca assamensis</i>
8.	Rhesus macaque	<i>Macaca mulatta</i>
9.	Capped langur	<i>Trachypithecus pileatus</i>
10.	Western Hoolock Gibbon	<i>Hoolock hoolock</i>
11.	Golden jackal	<i>Canis aureus</i>
12.	Sloth Bear	<i>Melursus ursinus</i>
13.	Eurasian Otter	<i>Lutra lutra</i>
14.	Small Indian Civet	<i>Viverricula indica</i>
15.	Small Asian Mongoose	<i>Herpestes javanicus</i>
16.	Indian Grey Mongoose	<i>herpestes edwardsii</i>
17.	Jungle cat	<i>Felis chaus</i>
18.	Leopard cat	<i>Prionailurus bengalensis</i>
19.	Leopard	<i>Panthera pardus</i>
20.	Tiger	<i>Panthera tigris</i>
21.	Asian Elephant	<i>Elephas maximus</i>
22.	Eurasian Wild pig of Wild boar	<i>Sus scrofa</i>
23.	Sambar	<i>Rusa unicolor</i>
24.	Barking deer or Southern Red Munthac	<i>Muntiacus muntjak</i>
25.	Malayan or Black Giant Squirrel	<i>Ratufa bicolor</i>
26.	Pallas's Squirrel	<i>Callosciurus erythraeus</i>
27.	Himalayan Hoary-bellied squirrel	<i>Callosciurus pygerythrus</i>
28.	Common or Red Giant Flying Squirrel	<i>Petaurista petaurista</i>
29.	Particoloured Flying Squirrel	<i>Hylopetes alboniger</i>
30.	Malayan or Himalayan Crestless Procupine	<i>Hystrix brachyura</i>
31.	Indian Hare	<i>Lepus nigricollis</i>
32.	South Asian River Dolphin	<i>Platanista gangetica</i>

ANNEXURE 14

Demography of Study Area Villages

Sl No.	Villages	No. of Household	Total Population	Household Size	% of Male Population	% of Female Population	Sex Ratio	% SC Population	% of ST Population
1	1 No. Dulia	209	1000	4.78	51.10	48.90	956.95	5.3	0.4
2	Amguri Nepali	159	842	5.30	49.05	50.95	1038.74	0	0.36
3	Balimora Chah Bagicha	236	1107	4.69	49.68	50.32	1012.73	0.63	0
4	Boragadhahi	1280	5213	4.07	51.16	48.84	954.63	3.41	4.68
5	Borhat Bagicha	1005	4865	4.84	50.38	49.62	984.90	0	0.23
6	Borkurukani	114	561	4.92	52.23	47.77	914.68	0	0
7	Chalakatak i No.1	113	520	4.60	48.85	51.15	1047.24	0	1.15
8	Chamaguri Gaon	423	2053	4.85	49.54	50.46	1018.68	0.97	0.39
9	Chapatali No.3	77	391	5.08	50.13	49.87	994.90	0	0
10	Chapatali No.4	97	464	4.78	49.57	50.43	1017.39	0	0
11	Cherepajan Bangali	60	255	4.25	51.76	48.24	931.82	0	0
12	Chetia Pathar	164	780	4.76	51.41	48.59	945.14	0	0.51
13	Chetia Pather No.1	29	138	4.76	50.00	50.00	1000.00	2.90	16.67
14	Chowdang Gaon	407	1941	4.77	50.49	49.51	980.61	0.21	37.51
15	Da-Hukuta	474	2283	4.82	51.55	48.45	939.68	9.33	1.40
16	Dalamuri No.2	122	592	4.85	50.34	49.66	986.58	0	5.07
17	Dihing Erasuti	106	522	4.92	52.30	47.70	912.09	0	6.13
18	Dihing Kinar Bangali No.2	14	71	5.07	50.70	49.30	972.22	0	15.49
19	Dihing Kinar Naga	61	325	5.33	51.08	48.92	957.83	0.31	3.08
20	Dihing Kinar Tiyoki	29	157	5.41	50.96	49.04	962.50	0	0
21	Direal	117	544	4.65	52.39	47.61	908.77	0.18	1.10
22	Dirial Gaon	51	225	4.41	54.67	45.33	829.27	0	15.11
23	Disang Kinar Bangali	77	379	4.92	51.45	48.55	943.59	5.80	1.32

Sl No.	Villages	No. of Household	Total Population	Household Size	% of Male Population	% of Female Population	Sex Ratio	% SC Population	% of ST Population
24	Duliajan No.2	413	1917	4.64	49.92	50.08	1003.13	6.62	0.57
25	Erapather	95	481	5.06	51.56	48.44	939.52	0	8.11
26	Fekelajan	23	111	4.83	51.35	48.65	947.37	0	0
27	Gariabam	198	1042	5.26	51.44	48.56	944.03	0	2.59
28	Gariabam Gaon	206	923	4.48	47.24	52.76	1116.97	0	3.36
29	Gelipung	82	413	5.04	51.09	48.91	957.35	0	5.33
30	Himalubam	41	219	5.34	51.60	48.40	938.05	0	1.83
31	Hindu Gaon	172	806	4.69	50.37	49.63	985.22	5.33	17.00
32	Jagun Majuli	0	0	0.00	0.00	0.00	0.00	0	0
33	Jaloni No.81	190	900	4.74	49.67	50.33	1013.42	0	0
34	Kathalguri No.2	255	1235	4.84	49.72	50.28	1011.40	0	35.87
35	Kamar Gaon	319	1451	4.55	47.76	52.24	1093.80	3.58	48.86
36	Maj Kapahuwa	261	1295	4.96	51.04	48.96	959.15	0	18.22
37	Merbil Majuli No.1	73	342	4.68	49.42	50.58	1023.67	0	0
38	Merbil Majuli No.2	103	490	4.76	50.82	49.18	967.87	0	0
39	Na-Choudang	62	324	5.23	51.85	48.15	928.57	0	0
40	Naharkatia Na Gaon	131	625	4.77	50.40	49.60	984.13	97.12	0.8
41	Noloni Pather	143	722	5.05	49.86	50.14	1005.56	32.69	11.22
42	Panch Suti Gaon	90	441	4.90	50.34	49.66	986.49	0	0
43	Chirika Beel	71	367	5.17	51.50	48.50	941.80	4.90	0.82
44	Panidaria Gaon	327	1527	4.67	50.56	49.44	977.98	0.33	6.94
45	Rajgar Rangali Pather (Rajgar Bangali Pathar)	342	1616	4.73	48.82	51.18	1048.16	0	0.06
46	Rangabani No.3 (Rangabam uni)	98	490	5.00	47.35	52.65	1112.07	0	0

Sl No.	Villages	No. of Household	Total Population	Household Size	% of Male Population	% of Female Population	Sex Ratio	% SC Population	% of ST Population
47	Sisumuria Borpather	79	386	4.89	51.81	48.19	930.00	0	0
48	Sripuria (Sriparia)	43	206	4.79	53.40	46.60	872.73	0	0
49	Telpani R/V	92	480	5.22	52.50	47.50	904.76	98.13	0.21
50	Tipling Purana Ghat	148	705	4.76	52.06	47.94	920.98	29.65	0
51	Tiyoki Block	31	151	4.87	49.01	50.99	1040.54	0	0
52	Usha Gaon	240	1239	5.16	51.49	48.51	942.01	0	1.13
53	Ushapur	38	194	5.11	45.88	54.12	1179.78	0	0
54	Ushapur Barbam Gaon	31	166	5.35	50.60	49.40	976.19	0	0
55	Uttar Somdar	530	2644	4.99	52.72	47.28	896.70	0	5.75
56	Gatong	91	471	5.18	52.44	47.56	906.88	0	0.00
57	Hil Kachubam	92	450	4.89	54.00	46.00	851.85	1.33	0.00
58	Mohmari Gaon No.1	228	1129	4.95	50.58	49.42	977.23	0	8.41
59	Mohmari Gaon No.2	242	1174	4.85	51.79	48.21	930.92	0	1.87
60	Tipomia Gaon	68	342	5.03	46.20	53.80	1164.56	0	0.00
61	Bokuloni No.2	399	1899	4.76	52.45	47.55	906.63	0.68	2.37
62	Dhekiyan Gaon No.1	219	1023	4.67	49.66	50.34	1013.78	0	13.39
63	Haatijan T.E. 110 Appl	158	838	5.30	49.88	50.12	1004.78	0	0.00
64	Hajua Pathar	141	656	4.65	51.52	48.48	940.83	1.22	23.78
65	Sasoni Pather Gaon	162	756	4.67	51.32	48.68	948.45	0	8.47
66	Sasoni	74	334	4.51	49.10	50.90	1036.59	0	26.65
67	Kerkoni No.1 (Kekuri No.2)	166	740	4.46	50.68	49.32	973.33	1.35	1.22
68	1 No. Bahoni Gaon	76	358	4.71	51.68	48.32	935.14	0	39.11
69	Duliajan Oil Town (CT)	6929	28626	4.13	52.04	47.96	921.47	6.32	3.17

Sl No.	Villages	No. of Household	Total Population	Household Size	% of Male Population	% of Female Population	Sex Ratio	% SC Population	% of ST Population
70	Joypur Town	520	2491	4.79	51.14	48.86	955.26	8.23	2.41
71	Namrup (CT)	3940	15719	3.99	52.08	47.92	920.00	3.63	7.52
72	Sarupathar Bengali (CT)	1956	8752	4.47	51.95	48.05	924.79	7.21	1.86

ANNEXURE 15

Literacy Profile Study Area Villages

Sl No.	Villages	Total Population	% Literate	% Male Literate	% Female Literate
1	1 No. Dulia	209	84.32	88.34	80.32
2	Amguri Nepali	159	85.98	90.58	81.63
3	Balimora Chah Bagicha	236	55.64	66.60	45.02
4	Boragadhahi	1280	91.41	93.81	88.91
5	Borhat Bagicha	1005	59.98	73.12	46.61
6	Borkurukani	114	79.63	86.45	72.34
7	Chalakataki No.1	113	87.18	91.42	82.98
8	Chamaguri Gaon	423	64.34	73.43	54.83
9	Chapatali No.3	77	77.19	88.41	65.38
10	Chapatali No.4	97	90.65	95.26	85.92
11	Cherepajan Bangali	60	97.40	100.00	94.69
12	Chetia Pathar	164	80.26	88.22	71.43
13	Chetia Pather No.1	29	82.20	87.30	76.36
14	Chowdang Gaon	407	90.46	94.42	86.38
15	Da-Hukuta	474	90.93	94.63	86.93
16	Dalamuri No.2	122	88.48	90.73	86.17
17	Dihing Erasuti	106	81.34	86.78	75.34
18	Dihing Kinar Bangali No.2	14	40.00	52.94	23.08
19	Dihing Kinar Naga	61	68.28	71.94	64.34
20	Dihing Kinar Tiyoki	29	78.03	88.06	67.69
21	Direal	117	75.10	85.66	63.44
22	Dirial Gaon	51	39.58	44.12	34.44
23	Disang Kinar Bangali	77	56.62	68.86	43.67
24	Duliajan No.2	413	85.09	89.99	80.07
25	Erapather	95	84.22	87.56	80.58
26	Fekelajan	23	95.74	95.83	95.65
27	Gariabam	198	64.09	69.84	58.04
28	Gariabam Gaon	206	79.56	91.32	69.21
29	Gelipung	82	77.84	85.48	69.71
30	Himalubam	41	52.97	62.37	43.48
31	Hindu Gaon	172	75.34	81.79	68.72
32	Jagun Majuli	0	0.00	0.00	0.00
33	Jaloni No.81	190	60.18	68.72	51.66
34	Kathalguri No.2	255	71.25	78.24	64.24
35	Kamar Gaon	319	84.01	89.92	78.60
36	Maj Kapahuwa	261	93.64	97.40	89.73
37	Merbil Majuli No.1	73	87.85	92.86	83.23
38	Merbil Majuli No.2	103	80.44	85.90	74.89
39	Na-Choudang	62	89.62	94.44	84.83
40	Naharkatia Na Gaon	131	91.59	96.23	87.04
41	Noloni Pather	143	92.80	97.46	88.06
42	Panch Suti Gaon	90	91.03	94.12	87.63
43	Chirika Beel	71	49.34	61.64	35.86
44	Panidaria Gaon	327	78.04	83.50	72.54
45	Rajgar Rangali Pather (Rajgar Bangali Pathar)	342	65.42	76.10	55.35

Sl No.	Villages	Total Population	% Literate	% Male Literate	% Female Literate
46	Rangabanani No.3 (Rangabamuni)	98	83.22	87.06	79.73
47	Sisumuria Borpathar	79	88.30	93.85	82.21
48	Sripuria (Sriparia)	43	84.83	85.26	84.34
49	Telpani R/V	92	81.05	88.73	72.34
50	Tipling Purana Ghat	148	87.18	92.33	81.38
51	Tiyoki Block	31	84.50	91.53	78.57
52	Usha Gaon	240	88.94	93.47	84.22
53	Ushapur	38	86.78	94.87	80.21
54	Ushapur Barbam Gaon	31	93.20	96.05	90.14
55	Uttar Somdar	530	72.53	79.77	64.55
56	Gatong	91	95.41	97.44	93.07
57	Hil Kachubam	92	94.59	94.37	94.85
58	Mohmari Gaon No.1	228	62.70	74.10	51.46
59	Mohmari Gaon No.2	242	52.65	66.40	37.84
60	Tipomia Gaon	68	64.07	72.66	56.41
61	Bokuloni No.2	399	75.28	82.11	67.71
62	Dhekiajan Gaon No.1	219	69.19	79.16	59.30
63	Haatijan T.E. 110 Appl	158	70.29	82.97	57.58
64	Hajua Pathar	141	82.34	88.12	76.22
65	Sasoni Pather Gaon	162	93.75	95.69	91.76
66	Sasoni	74	88.07	95.80	80.28
67	Kerkoni No.1 (Kekuri No.2)	166	86.01	90.38	81.46
68	1 No. Bahoni Gaon	76	84.28	90.48	77.33
69	Duliajan Oil Town (CT)	6929	93.98	96.57	91.16
70	Joypur Town	520	89.31	94.17	84.14
71	Namrup (CT)	3940	92.88	94.85	90.75
72	Sarupathar Bengali (CT)	1956	91.48	95.20	87.47

ANNEXURE 16

Workforce Participation of Study Area Villages

Sl No.	Villages	Total Population	Total worker Population	% Cultivator	% Agricultural Labor	% Household industry worker	% other worker
1	1 No. Dulia	209	357	13.73	13.45	4.76	68.07
2	Amguri Nepali	159	399	87.72	4.51	0.50	7.27
3	Balimora Chah Bagicha	236	489	0.82	0.61	0.00	98.57
4	Boragadhahi	1280	2236	2.46	1.83	3.94	91.77
5	Borhat Bagicha	1005	2458	1.26	0.53	0.77	97.44
6	Borkurukani	114	433	81.52	3.00	7.39	8.08
7	Chalakataki No.1	113	210	13.81	15.71	3.33	67.14
8	Chamaguri Gaon	423	789	5.96	1.14	0.89	92.02
9	Chapatali No.3	77	207	22.22	62.32	4.35	11.11
10	Chapatali No.4	97	260	70.77	14.23	0.77	14.23
11	Cherepajan Bangali	60	73	12.33	1.37	6.85	79.45
12	Chetia Pathar	164	281	22.06	0.71	0.36	76.87
13	Chetia Pather No.1	29	83	21.69	65.06	3.61	9.64
14	Chowdang Gaon	407	912	73.90	2.30	1.54	22.26
15	Da-Hukuta	474	850	15.76	12.00	10.35	61.88
16	Dalamuri No.2	122	335	88.96	6.27	0.00	4.78
17	Dihing Erasuti	106	293	67.58	5.12	0.00	27.30
18	Dihing Kinar Bangali No.2	14	29	100.00	0.00	0.00	0.00
19	Dihing Kinar Naga	61	154	61.69	16.23	0.00	22.08
20	Dihing Kinar Tiyoki	29	71	33.80	61.97	0.00	4.23
21	Direal	117	200	28.00	17.00	19.00	36.00
22	Dirial Gaon	51	64	3.13	1.56	0.00	95.31
23	Disang Kinar Bangali	77	175	21.71	12.00	4.00	62.29
24	Duliajan No.2	413	650	0.77	0.62	0.46	98.15
25	Erapather	95	279	18.28	50.90	7.17	23.66
26	Fekelajan	23	57	87.72	5.26	5.26	1.75
27	Gariabam	198	423	47.75	6.62	0.00	45.63
28	Gariabam Gaon	206	392	6.38	2.04	2.04	89.54
29	Gelipung	82	286	38.46	44.41	0.00	17.13
30	Himalubam	41	71	21.13	0.00	0.00	78.87
31	Hindu Gaon	172	284	50.00	0.35	2.11	47.54
32	Jagun Majuli	0	0	0	0	0	0
33	Jaloni No.81	190	393	0.51	0.00	0.00	99.49
34	Kathalguri No.2	255	499	31.26	31.86	4.81	32.06
35	Kamar Gaon	319	656	31.86	4.12	8.08	55.95

Sl No.	Villages	Total Population	Total worker Population	% Cultivator	% Agricultural Labor	% Household industry worker	% other worker
36	Maj Kapahuwa	261	439	60.82	16.86	3.42	18.91
37	Merbil Majuli No.1	73	105	22.86	0.95	0.00	76.19
38	Merbil Majuli No.2	103	207	4.83	33.33	0.48	61.35
39	Na-Choudang	62	96	54.17	8.33	0.00	37.50
40	Naharkatia Na Gaon	131	321	10.59	1.56	0.00	87.85
41	Noloni Pather	143	212	11.79	5.66	4.72	77.83
42	Panch Suti Gaon	90	292	29.45	29.45	1.37	39.73
43	Chirika Beel	71	127	18.11	38.58	2.36	40.94
44	Panidaria Gaon	327	661	29.65	0.45	1.21	68.68
45	Rajgar Rangali Pather (Rajgar Bangali Pathar)	342	668	27.69	8.53	1.50	62.28
46	Rangabanani No.3 (Rangabamuni)	98	302	87.09	8.61	0.66	3.64
47	Sisumuria Borpathar	79	239	96.23	1.67	0.42	1.67
48	Sripuria (Sripuria)	43	122	24.59	50.00	0.00	25.41
49	Telpani R/V	92	243	47.74	2.88	17.70	31.69
50	Tipling Purana Ghat	148	188	13.83	7.98	3.72	74.47
51	Tiyoki Block	31	30	96.67	0.00	0.00	3.33
52	Usha Gaon	240	442	47.06	7.92	3.62	41.40
53	Ushapur	38	120	57.50	7.50	0.00	35.00
54	Ushapur Barbam Gaon	31	47	40.43	12.77	0.00	46.81
55	Uttar Somdar	530	981	63.51	5.61	0.10	30.78
56	Gatong	91	322	98.76	0.31	0.93	0.00
57	Hil Kachubam	92	282	87.23	4.96	1.42	6.38
58	Mohmari Gaon No.1	228	314	11.46	10.19	4.14	74.20
59	Mohmari Gaon No.2	242	539	16.70	3.90	0.56	78.85
60	Tipomia Gaon	68	118	8.47	1.69	2.54	87.29
61	Bokuloni No.2	399	690	13.91	2.90	1.88	81.30
62	Dhekiajan Gaon No.1	219	417	22.78	3.60	0.00	73.62
63	Haatijan T.E. 110 Appl	158	363	0.55	6.06	0.00	93.39
64	Hajua Pathar	141	257	9.73	1.17	4.28	84.82
65	Sasoni Pather Gaon	162	324	65.12	3.70	4.01	27.16
66	Sasoni	74	192	91.67	2.08	0.00	6.25

Sl No.	Villages	Total Population	Total worker Population	% Cultivator	% Agricultural Labor	% Household industry worker	% other worker
67	Kerkoni No.1 (Kekuri No.2)	166	245	22.45	6.53	13.06	57.96
68	1 No. Bahoni Gaon	76	93	68.82	12.90	0.00	18.28
69	Duliajan Oil Town (CT)	6929	9882	0.30	0.65	1.13	97.92
70	Joypur Town	520	810	5.43	1.11	3.09	90.37
71	Namrup (CT)	3940	6200	2.85	6.29	2.97	87.89
72	Sarupathar Bengali (CT)	1956	2923	0.17	0.38	2.53	96.92

ANNEXURE 17

Risk Assessment

RISK ASSESSMENT

This section on Risk Assessment (RA) aims to provide a systematic analysis of the major risks that may arise from 67 onshore development well drilling and laying of oil and gas pipeline in Jorajan Block. The RA process outlines rational evaluations of the identified risks based on their significance and provides the outline for appropriate preventive and risk mitigation measures. Results of the RA provides valuable inputs into the overall project planning and the decision making process for effectively addressing the identified risks. This will ensure that the project risks stay below As Low As Reasonably Practicable (ALARP) levels at all times during project implementation. In addition, the RA will also help in assessing risks arising from potential emergency situations like a blow out and develop a structured Emergency Response Plan (ERP) to restrict damage to personnel, infrastructure and the environment.

The risk study for the onshore drilling and testing activities has considered all aspects of operation of the drilling rig and other associated activities during the development phase. Loss of well control / blow-out and process/pipeline leaks constitute the major potential hazards that may be associated with the proposed onshore development of oil and natural gas at the identified well locations within the Jorajan Block.

The following section describes objectives, methodology of the risk assessment study and then presents the assessment for each of the potential risk separately. This includes identification of major hazards, hazard screening and ranking, frequency and consequence analysis for major hazards. The hazards have subsequently been quantitatively evaluated through a criteria based risk evaluation matrix. Risk mitigation measures to reduce significant risks to acceptable levels have also been recommended as a part of the risk assessment study.

OBJECTIVE OF THE RA STUDY

The overall objective of this RA with respect to the proposed project involves identification and evaluation of major risks, prioritizing risks identified based on their hazard consequences and formulating suitable risk reduction/mitigation measures in line with the ALARP principle. Hence in order to ensure effective management of any emergency situations (with potential individual and societal risks) that may arise during the development drilling activities, following specific objectives need to be achieved.

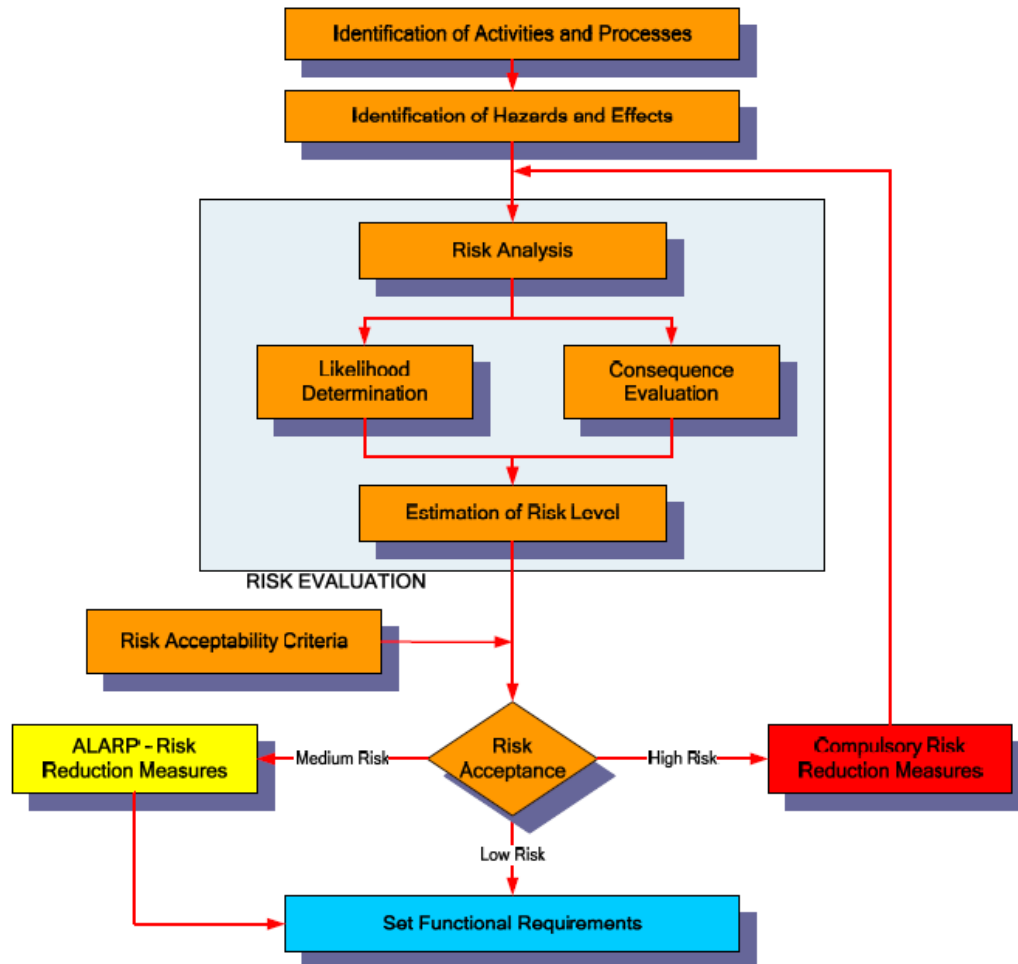
- Identify potential risk scenarios that may arise out of proposed development well drilling, operations of trunk and assorted oil and gas pipelines and associated equipment's, mud chemicals storage and handling etc.
- Analyse the possible likelihood and frequency of such risk scenarios by reviewing historical accident related data for onshore oil and gas industries.

- Predict the consequences of such potential risk scenarios and if consequences are high, establish the same by through application of quantitative simulations.
- Recommend feasible preventive and risk mitigation measures as well as provide inputs for drawing up of Emergency Response Plan (ERP) for the Project.

RISK ASSESSMENT METHODOLOGY

The risk assessment process is primarily based on likelihood of occurrence of the risks identified and their possible hazard consequences particularly being evaluated through most probable and worst case accident scenarios. With respect to the proposed Project, the methodology adopted for risk assessment is summarized in the Figure 1.

Figure 1 Risk Assessment Methodology



Hazard Identification

Hazard identification for the purposes of this RA comprised of a review of the Project and associated activity related information provided by OIL. In addition, guidance provided by knowledge platforms/portals of the upstream oil & gas industry including OGP, ITOFP, EGIG and DNV, Norwegian

Petroleum Directorate etc. are used to identify potential hazards that can arise out of the proposed Project activities. Considering the applicability of different risk aspects in context of the development drilling operations to be undertaken in the identified well locations, there are three major categories of hazards that can be associated with proposed Project.. These include:

- Blowouts leading to uncontrolled well flow, jet fires, flash fire from flammable cloud, pool fires;
- Non-process fires / explosions, the release of a dangerous substance or any other event resulting from a work activity which could result in death or serious injury to people within the site;
- Leaks from interconnecting pipeline network/trunk pipeline leading to jet fire; and
- Any event which may result in major damage to the structure of the rig

Well control incident covers a range of events which have the potential of leading to blow-outs but are generally controlled by necessary technological interventions. Hence, such incidents are considered of minor consequences and as a result not well documented. Other possible hazard scenarios like mud chemical spills, falls, etc. has also not been considered for detailed assessment as preliminary evaluation has indicated that the overall risk that may arise out of them would be low. In addition, it is understood that, causative factors and mitigation measures for such events can be adequately taken care of through exiting safety management procedures and practices of OIL.

It must also be noted here that many hazards identified are sometimes interrelated with one hazard often having the ability to trigger off another hazard through a domino effect. For example, a large oil spill in most instances is caused by another hazardous incident like a blowout or process leak. This aspect has been considered while drawing up hazard mitigation measures and such linkages (between hazards) has also been given due importance for managing hazards and associated risks in a composite manner through OIL's Health, Safety & Environmental Management System (HSEMS) and through the Emergency Response Plan (ERP), if a contingency situation so arises.

Frequency Analysis

Frequency analysis involves estimating the likelihood of each of the failure cases identified during the hazard identification stage. The analysis of frequencies of occurrences for the key hazards that has been listed out is important to assess the likelihood of such hazards to unfold during the lifecycle of the project. The frequency analysis approach for the proposed Project is based primarily on historical accident frequency data, event tree analysis and judgmental evaluation. Major oil and gas industry information

sources viz. statistical data, historical records and global industry experience were considered during the frequency analysis of the major identified risks¹.

For RA for the proposed Project, various accident statistics and published oil industry databases have been consulted for arriving at probable frequencies of identified hazards. However, taking into account the absence of representative historical data/statistics with respect to onshore operations², relevant offshore accident databases have been considered in the frequency analysis of identified hazards. The same has been recommended in the “*Risk Assessment Data Directory*” published by the International Association of Oil & Gas Producers (OGP). Key databases/reports referred as part of the QRA study includes Worldwide Offshore Accident Databank (WOAD), Outer Continental Shelf (OCS) Reports, Norwegian Petroleum Directorate Directives, Offshore Reliability Data (OREDA) Handbook, HSE Offshore Incident Database, SINTEF Offshore Blowout Database etc.

Based on the range of probabilities arrived at for different potential hazards that may be encountered during the proposed well development activities, following criteria for likelihood rankings have been drawn up as presented in the Table 1.

Table 1 Frequency Categories and Criteria

Likelihood Ranking	Criteria Ranking (cases/year)	Frequency Class
5	>1.0	Frequent
4	>10 ⁻¹ to <1.0	Probable
3	>10 ⁻³ to <10 ⁻¹	Occasional/Rare
2	>10 ⁻⁵ to <10 ⁻³	Not Likely
1	>10 ⁻⁶ to <10 ⁻⁵	Improbable

Consequence Analysis

In parallel to frequency analysis, hazard prediction / consequence analysis exercise assesses resulting effects in instances when accidents occur and their likely impact on project personnel, infrastructure and environment. In relation to the proposed Project, estimation of consequences for each possible event has been based either on accident experience, consequence modelling or professional judgment, as appropriate.

Given the high-risk perception associated with blow outs in context of onshore drilling operation, a detailed analysis of consequences has been undertaken for blow outs considering physical factors and technological interventions. Consequences of such accidental events on the physical, biological and socio-economic environment have been studied to evaluate the potential of the identified risks/hazards. In all, the consequence analysis considers the following aspects:

- Nature of impact on environment and community;

¹It is to be noted that the frequency of occurrences are usually obtained by a combination of component probabilities derived on basis of reliability data and /or statistical analysis of historical data.

²Although Alberta Energy & Utilities Board (EUB) maintains a database for onshore incidents for the period 1975-1990 the same has not been considered in the context of the present study as the Alberta wells are believed to be sour with precaution being taken accordingly to minimize the likelihood of release

- Occupational health and safety;
- Asset and property damage;
- Corporate image
- Timeline for restoration of environmental and property damage
- Restoration cost for environmental and property damage.

The following criterion for consequence rankings (Table 2) is drawn up in context of the possible consequences of risk events that may occur during proposed well development activities:

Table 2 *Severity Categories and Criteria*

Consequence	Ranking	Criteria Definition
Catastrophic	5	<ul style="list-style-type: none"> • Multiple fatalities/Permanent total disability to more than 50 persons • Severe violations of national limits for environmental emission • More than 5 years for natural recovery • Net negative financial impact of >10 crores • Long term impact on ecologically sensitive areas • International media coverage • National stakeholder concern and media coverage
Major	4	<ul style="list-style-type: none"> • Single fatality/permanent total disability to one or more persons • Major violations of national limits for environmental emissions • 2-5 years for natural recovery • Net negative financial impact of 5 -10 crores • Significant impact on endangered and threatened floral and faunal species • Loss of corporate image and reputation
Moderate	3	<ul style="list-style-type: none"> • Short term hospitalization & rehabilitation leading to recovery • Short term violations of national limits for environmental emissions • 1-2 years for natural recovery • Net negative financial impact of 1-5 crores • Short term impact on protected natural habitats • State wide media coverage
Minor	2	<ul style="list-style-type: none"> • Medical treatment injuries • 1 year for natural recovery • Net negative financial impact of 0.5 - 1 crore • Temporary environmental impacts which can be mitigated • Local stakeholder concern and public attention
Insignificant	1	<ul style="list-style-type: none"> • First Aid treatment with no Lost Time Incidents (LTIs) • Natural recovery < 1year • Net negative financial impact of <0.5 crores. • No significant impact on environmental components • No media coverage

Risk Evaluation

Based on ranking of likelihood and frequencies, each identified hazard has been evaluated based on the likelihood of occurrence and the magnitude of consequences. Significance of risks is expressed as the product of likelihood and consequence of the risk event, expressed as follows:

$$\text{Significance} = \text{Likelihood} \times \text{Consequence}$$

The Table 3 below illustrates all possible product results for five likelihood and consequence categories while the Table 4 assigns risk significance criteria in four regions that identify the limit of risk acceptability. Depending on the position of intersection of a column with a row in the risk matrix, hazard prone activities have been classified as low, medium and high thereby qualifying a set of risk reduction / mitigation strategies.

Table 3 Risk Matrix

		Likelihood →					
			Frequent	Probable	Remote	Not Likely	Improbable
			5	4	3	2	1
Consequence ↑	Catastrophic	5	25	20	15	10	5
	Major	4	20	16	12	8	4
	Moderate	3	15	12	9	6	3
	Minor	2	10	8	6	4	2
	Insignificant	1	5	4	3	2	1

Table 4 Risk Criteria and Action Requirements

Risk Significance	Criteria Definition & Action Requirements
High (16 - 25)	"Risk requires attention" – Project HSE Management need to ensure that necessary mitigation are adopted to ensure that possible risk remains within acceptable limits
Medium (10 - 15)	"Risk is tolerable" – Project HSE Management needs to adopt necessary measures to prevent any change/modification of existing risk controls and ensure implementation of all practicable controls.
Low (5 - 9)	"Risk is acceptable" – Project related risks are managed by well-established controls and routine processes/procedures. Implementation of additional controls can be considered.

IDENTIFIED PROJECT HAZARDS

A comprehensive risk assessment study has been undertaken to assess and evaluate significance of identified risks in terms of severity of consequences and likelihood of occurrence. Three major categories of risks are identified in relation to proposed development Project as summarized below:

Blow Outs/Loss of Well Control

Blow out is an uncontrolled release of well fluid (primarily hydrocarbons viz. oil and/or gas and may also include drilling mud, completion fluid, water etc.) from an exploratory or development well. Blow outs are the result of failure to control a kick and regain pressure control and are typically caused by equipment failure or human error. The possible blow out cause events occurring in isolation or in combination have been listed below:

- Formation fluid entry into well bore;
- Loss of containment due to malfunction (viz. wire lining);
- Well head damage (e.g., by fires, storms, dropped object etc.); and
- Rig forced off station (e.g., by anchor failure) damaging Blow Out Preventer (BOP) or wellhead.

The most common cause of blow out can be associated with the sudden/unexpected entry/release of formation fluid into well bore that may arise as a result of the following events as discussed in the ***Box 1*** below:

Box 1 Primary Causes of Blow Outs

Shallow gas

In shallow formations there may be pockets of shallow gas. In these instances, there is often insufficient mud density in the well and no BOP is in place. If the hole strikes shallow gas the gas may be released on the drilling rig very rapidly. Typical geological features which suggest the presence of shallow gas can then be detected. Historically, striking of shallow gas has been one of the most frequent causes of blowouts in drilling.

Swabbing

As the drill pipe is pulled upwards during trips out of the hole or upward movement of the drill string, the pressure in the hole beneath the drill bit is reduced, creating a suction effect. Sufficient drilling mud must be pumped down-hole to compensate for this effect or well fluids may enter the bore. Swabbing is also a frequent cause of drilling blowouts.

High formation pressure

Drilling into an unexpected zone of high pressure may allow formation fluids to enter the well before mud weight can be increased to prevent it.

Insufficient mud weight

The primary method of well control is the use of drilling mud; in correct operation, the hydrostatic pressure exerted by the mud prevents well fluids from entering the well bore. A high mud weight provides safety against well fluids in-flows. However, a high mud weight reduces drilling speed, therefore, mud weight is calculated to establish weight most suitable to safely control anticipated formation pressures and allows optimum rates of penetration. If the required mud weight is incorrectly calculated, then well fluid may be able to enter the bore.

Lost Circulation

Drilling mud circulation can be lost if mud enters a permeable formation instead of returning to the rig. This reduces the hydrostatic pressures exerted by the mud throughout the well bore and may allow well fluids from another formation to enter the bore.

Gas cut mud

Drilling fluids are denser than well fluids; this density is required to provide the hydrostatic pressure which prevents well fluids from entering the bore. If well fluids mix with the mud, then its density will be reduced. As mud is circulated back to surface, hydrostatic pressure exerted by the mud column is reduced. Once gas reaches surface it is released into the atmosphere.

Source: A Guide to Quantitative Risk Assessment for Offshore Installations; John Spouge – DNV Technical Publication 99/100a

For better understanding, causes of blow outs have been systematically defined in terms of loss of pressure control (failure of primary barrier), uncontrolled flow of fluid or failure of secondary barrier (BOP). The blow out incidents resulting from primary and secondary failures as obtained through comprehensive root cause analysis of the Gulf Coast (Texas, OCS and US Gulf of Mexico) Blow Outs¹ during 1960-1996 have been presented in the Table 5 below.

Table 5 Blow Out Cause Distribution for Failures during Drilling Operations

Sl. No.	Causal Factors	Blow Out Incidents (Nos.)
A.	Primary Barrier	
1	Swabbing	77
2	Drilling Break	52
3	Formation breakdown	38
4	Trapped/expanding gas	09
5	Gas cut mud	26

¹ "Trends extracted from 1200 Gulf Coast blowouts during 1960-1996" – Pal Skalle and A.L Podio

Sl. No.	Causal Factors	Blow Out Incidents (Nos.)
6	Low mud weight	17
7	Wellhead failure	05
8	Cement setting	05
B.	Secondary Barrier	
1	Failure to close BOP	07
2	Failure of BOP after closure	13
3	BOP not in place	10
4	Fracture at casing shoe	03
5	Failure to stab string valve	09
6	Casing leakage	06

Thus, underlying blowout causes as discussed in the above table can be primarily attributed to swabbing as the primary barrier failure which is indicative of insufficient attention given to trip margin and controlling pipe movement speed. Also, it is evident from the above table that lack of proper maintenance, operational failures and absence of BOPs as secondary barrier contributed to majority of blowout incidents (approx. 30 nos.) is recorded.

Blowout Frequency Analysis

Blow out frequency estimates is obtained from a combination of incident experience and associated exposure in an area over a given period. For the purpose of calculation of blow out frequency analysis in context of the present study involving developmental drilling, blow out frequencies per well drilled have been considered.

For onshore operations, comparable data were not found hence offshore data presented here, the fraction of subsea releases compiled by DNV have been considered for frequency analysis. Based on the given frequency and information provided by OIL on the proposed project drilling program the blow out frequency for the proposed Project has been computed as follows:

No of wells to be drilled per year = 15 (A)
Blow out frequency for development drilling (oil) = 2.62×10^{-5} per well drilled (B)
Blow out frequency for development drilling (gas) = 2.16×10^{-5} per well drilled (C)
Frequency of blow out occurrence for the proposed project (oil) = $(A \times B) = 15 \times 2.62 \times 10^{-5}$ = 3.9×10^{-4} per well drilled
Frequency of blow out occurrence for the proposed project (gas) = $(A \times C) = 15 \times 2.16 \times 10^{-5}$ = 3.2×10^{-4} per well drilled

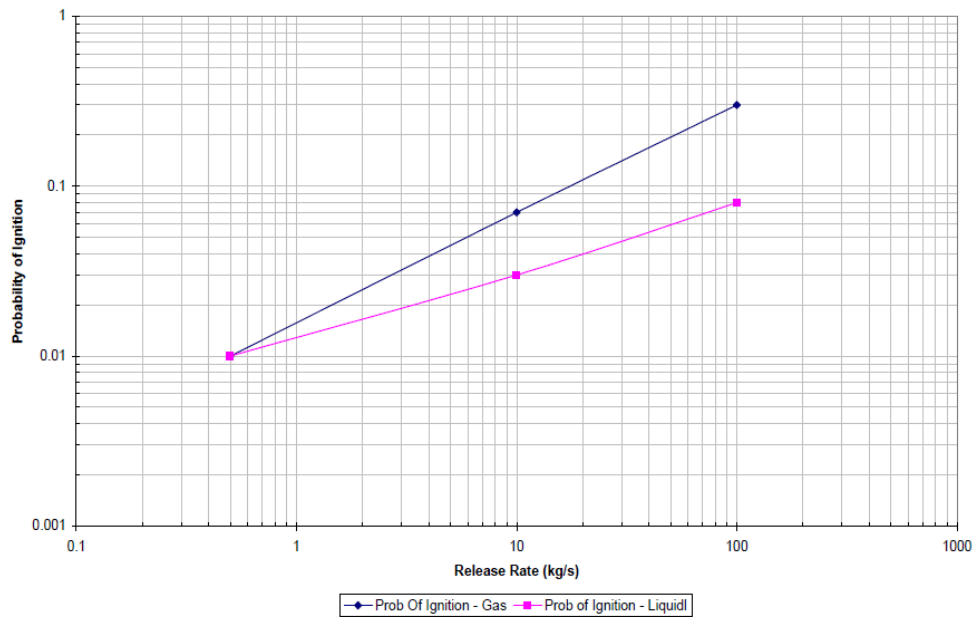
Thus, the blow out frequency for the proposed project for oil and gas wells have been at 3.9×10^{-4} and 3.2×10^{-4} per well drilled per year respectively i.e. **the likelihood of its occurrence is identified to be as “Not Likely”**

Blowout Ignition Probability

Review of SINTEF database indicates that a rounded ignition probability of 0.3 has been widely used for the purpose of quantitative risk analysis arising from blow outs. As per this database generally ignition occurred within first 5 minutes in approximately 40% of the blowouts leading to either pool and/or

jet fire. Blow out leading to flammable gas release has a greater probability of ignition compared to liquid releases¹ (Figure 2).

Figure 2 Ignition Probability Vs Release Rate



An alternative to the blowout ignition probabilities given by the UKOOA look-up correlations can be obtained from Scandpowers’s interpretation of the blowout data provided by SINTEF 2. The most significant category is that for deep blowouts which indicates an early ignition probability of 0.09. For the purpose of the RA study this can be taken as occurring immediately on release and calculation provided below:

No of wells to be drilled per year = 15(A)	
Blow out frequency for development drilling (oil) = 2.62×10^{-5} per well drilled (B)	
Blow out frequency for development drilling (gas) = 2.16×10^{-5} per well drilled (C)	
Blow out ignition probability = 0.09 (D)	
Probability of Blow out ignition for the proposed project (oil) = (A X B X D) = $15 \times 2.62 \times 10^{-5} \times 0.09$	
	= 3.53×10^{-5} = ~ 0.003%
Probability of Blow out ignition for the proposed project (gas) = (A X C X D) = $15 \times 2.16 \times 10^{-5} \times 0.09$	
	= 2.91×10^{-5} = ~ 0.002%

Hence based on the aforesaid calculation the probability of ignition of blow out releases of hydrocarbons for the proposed development project for both oil and gas is computed to be around 3.53×10^{-5} (0.0035%) and 2.91×10^{-5} (0.0029%) respectively and can be Not Likely.

Blowout Consequence Analysis

Blow out from a hydrocarbon development wells may lead to the following possible risk consequences:

¹Fire and Explosion - Fire Risk Analysis by Daejun Change, Division of Ocean System and Engineering

- a. Jet fires resulting from ignited gas blow outs; and
- b. Oil slicks resulting from un-ignited oil pools.

Pool fire

A pool fire is a turbulent diffusion fire burning above a pool of vaporizing hydrocarbon fuel where the fuel vapour has negligible initial momentum. The probability of occurrence of pool fires for oil and gas exploration is high due to continuous handling of heavy hydrocarbons. The evaporation of hydrocarbons from a pool forms a cloud of vapour above the pool surface which, on ignition, leads to generation of pool fire.

For the purpose of consequence modelling for pool fires resulting from blow outs, following hypothetical scenarios in terms of hydrocarbon (particularly crude oil) release rates (Table 6) have been considered based on DNV Technica’s FLARE program.

Table 6 Pool Fire Modelling Scenario

Scenario	Release Rate (kg/s)	Release Type
Scenario - I	1	Small
Scenario - II	10	Medium
Scenario - III (Worst Case)	50	Large

The release rates as specified for the aforesaid scenarios have been utilized in the computing the pool fire diameter utilizing the following equation and input parameters:

$$D = \sqrt{4Q/\pi b}$$

Where D = pool diameter (m)

Q = release rate (kg/s)

b = burning rate (kg/m²s)

The mass burning rate for crude oil has been considered to be 0.05 kg/m²s

Based on above equation, the pool fire diameter and the steady study burning areas computed for various release types have been presented in the Table 7 below.

Table 7 Pool Fire Diameter & Steady State Burning Scenario

Scenario	Release Rate (kg/s)	Release Type	Pool fire diameter (m)	Steady State Burning Area (m ²)
Scenario - I	1	Small	5.05	6.37
Scenario - II	10	Medium	15.96	63.69
Scenario - III	50	Large	35.69	318.47

The impact zone for long duration fires is conveniently described by thermal radiation contours and its effects on the people who are exposed to such radiation levels for one minute (60sec). The thermal radiation threshold values

(measured in kilowatts per square meter) defined for crude oil pool fire consequence modelling is provided in Table 8 below:

Table 8 Thermal Radiation Intensity Threshold Values Impact Criterion

Threshold Radiation Intensity	Threat Zone	Impact Criterion
5.0 kW/m ²	Green	<ul style="list-style-type: none"> Escape actions within one minute. Cause second degree burns within 60 sec.
12.5 kW/m ²	Blue	<ul style="list-style-type: none"> Escape actions lasting for few seconds. Cause second degree burns within 40 sec.
37.5 kW/m ²	Red	<ul style="list-style-type: none"> Results in immediate fatality. Pain threshold is instantaneous leading to second degree burns within 8 sec.

For estimating the distance to a pool fire heat radiation level that could cause second degree burns and fatality for a maximum exposure of 60 sec the following EPA equation and input parameters are utilized.

$$X = H_c \sqrt{\frac{0.0001 A}{5000 \Pi (H_v + C_p (T_B - T_A))}}$$

Where:

X = distance to the heat radiation level (m)

HC = heat of combustion of the flammable liquid (joules/kg)

HV = heat of vaporization of the flammable liquid (joules/kg)

A = pool area (m²)

CP = liquid heat capacity (joules/kg-K)

TB = boiling temperature of the liquid (K)

TA = ambient temperature (K)

For crude oil **HC = 42600000 joules/kg; HV = 957144 joules/kg; CP = 1892 joules/kg-K; TB = 633 K** and **TA = 300 K**. The following input parameter along with pool area (m²) computed for blow out risk scenarios provided the distance to the threshold heat radiation levels for the threat zones and have been presented in Table 9 below

Table 9 Distance to Thermal Radiation Threshold Levels

Release Type	Pool fire diameter (m)	Pool fire area (m ²)	Distance to 5.0 kW/m ² (m)	Distance to 12.5 kW/m ² (m)	Distance to 37.5 kW/m ² (m)
Small	5.05	6.37	6.81	4.31	2.49
Medium	15.96	63.69	21.54	13.62	7.86
Large	35.69	318.47	48.16	30.46	17.59

The worst hazard for release and ignition of crude oil at a rate of **50kg/s** for a thermal radiation intensity of **37.5 kW/m²** is likely to be experienced to a maximum distance of **17.59m** from the source with potential lethal effects experienced within 8 sec.

Risk Ranking – Blowout Pool Fire (Worst Case Scenario)

Likelihood ranking	3	Consequence ranking	4
Risk Ranking & Significance = 12 i.e. "Medium" i.e. Risk is Tolerable and can be managed through adoption of necessary controls.			

Ignition of Flammable Gas Release leading to Jet Fire

Jet fires are burning jet of gas or sprays of atomized liquids resulting from gas and condensate release from high pressure equipment and blow outs. Jet fires may also result in the release of high pressure liquid containing dissolved gas due to gas flashing off and turning the liquid into a spray of small droplets. In context of the present study, formation of jet fires can be attributed by the high pressure release and ignition of natural gas if encountered during exploration of block hydrocarbon reserves.

Natural gas as recovered from underground deposits primarily contains methane (CH₄) as a flammable component, but it also contains heavier gaseous hydrocarbons such as ethane (C₂H₆), propane (C₃H₈) and butane (C₄H₁₀). Other gases such as CO₂, nitrogen and hydrogen sulfide (H₂S) are also often present. Methane is typically 90 percent, ethane 5-15 percent, propane and butane, up to 5 percent. Thus, considering higher percentage of methane in natural gas, the thermo-chemical properties of the same has been utilized in the jet fire blow out consequence modelling. The following risk scenarios (Table 10) have been considered for nature gas release consequence modelling:

Table 10 Natural Gas Release/Flammable Vapour Cloud Formation Modelling Scenario from Blow Outs

Scenario	Release Rate (kg/s)	Release Type
Scenario - I	1	Small
Scenario - II	5	Medium
Scenario - III	10	Large
Scenario - IV	310	Worst Case

The modelling of nature gas releases has been carried out using ALOHA. A Flammable Level of Concern approach has been utilized for assessing safety risk associated with the release of flammable gases (here methane) from well blow outs. In ALOHA, a flammable Level of Concern (LOC) is a threshold concentration of fuel in the air above which a flammability hazard may exist. While modelling the release of a flammable gas that may catch fire – but which is not currently burning – ALOHA can predict the flammable area of the vapour cloud so that flammability hazard can be established.

The flammable area is the part of a flammable vapour cloud where the concentration is in the flammable range, between the Lower and Upper Explosive Limits (LEL and UEL). These limits are percentages that represent the concentration of the fuel (that is, the chemical vapour) in the air. If the chemical vapour comes into contact with an ignition source (such as a spark), it will burn only if its fuel-air concentration is between the LEL and the UEL –

because that portion of the cloud is already pre-mixed to the right mixture of fuel and air for burning to occur. If the fuel-air concentration is below the LEL, there is not enough fuel in the air to sustain a fire or an explosion – it is too lean. If the fuel-air concentration is above the UEL, there is not enough oxygen to sustain a fire or an explosion because there is too much fuel – it is too rich.

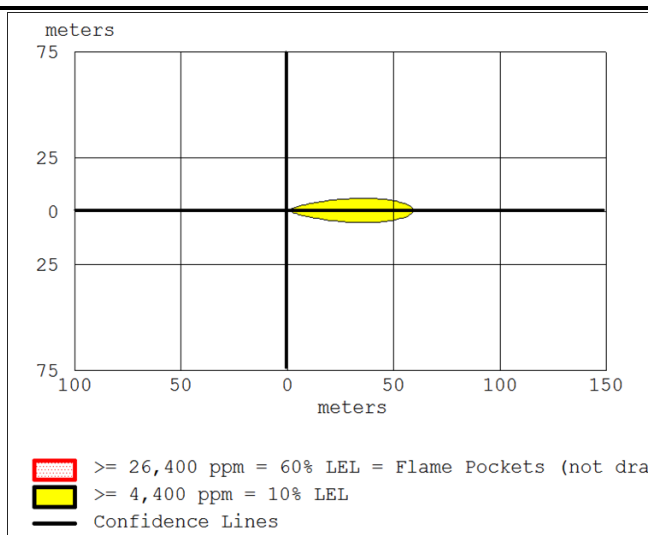
When a flammable vapour cloud is dispersing, the concentration of fuel in the air is not uniform; there will be areas where the concentration is higher than the average and areas where the concentration is lower than the average. This is called concentration patchiness. Because of concentration patchiness, there will be areas (called pockets) where the chemical is in the flammable range even though the average concentration has fallen below the LEL. Because of this, ALOHA's default flammable LOCs are each a fraction of the LEL, rather than the LEL itself. ALOHA uses 60% of the LEL as the default LOC for the red threat zone, because some experiments have shown that flame pockets can occur in places where the average concentration is above that level. Another common threat level used by responders is 10% of the LEL, which is ALOHA's default LOC for the yellow threat zone. The flammable LOC threat zones for methane release are as follows:

Red : 26,400 ppm = 60% LEL = Flame Pockets

Yellow: 4,400 ppm = 10% LEL

Well site risk contour maps for worst case scenario prepared based on ALOHA modeling of natural gas releases for flammable vapour cloud has been presented in *Figures 3-6* below.

Figure 3 Scenario I: Risk Contour Map



THREAT ZONE:

Threat Modelled: Flammable Area of Vapour Cloud

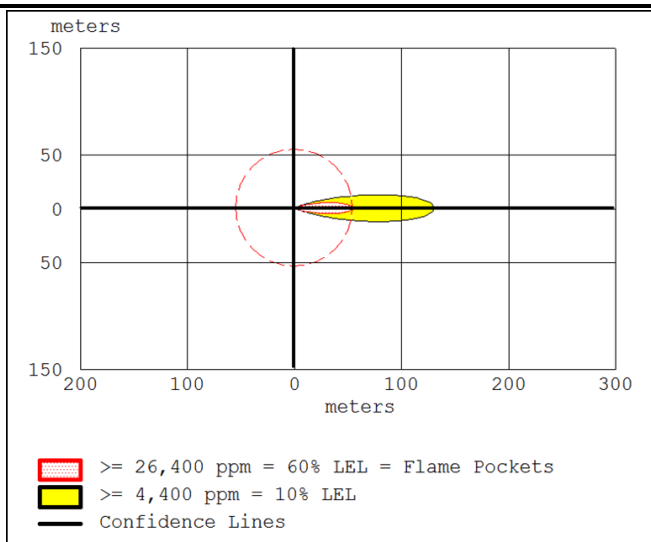
Model Run: Gaussian

Red : 25 meters --- (26,400 ppm = 60% LEL = Flame Pockets)

Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

Yellow: 60 meters --- (4,400 ppm = 10% LEL)

Figure 4 Scenario II: Risk Contour Map



THREAT ZONE:

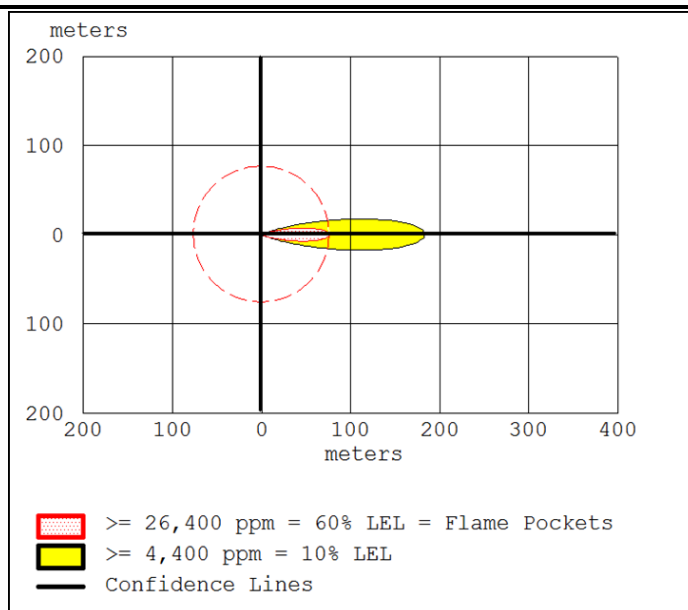
Threat Modeled: Flammable Area of Vapour Cloud

Model Run: Gaussian

Red : 55 meters --- (26,400 ppm = 60% LEL = Flame Pockets)

Yellow: 131 meters --- (4,400 ppm = 10% LEL)

Figure 5 Scenario III: Risk Contour Map



THREAT ZONE:

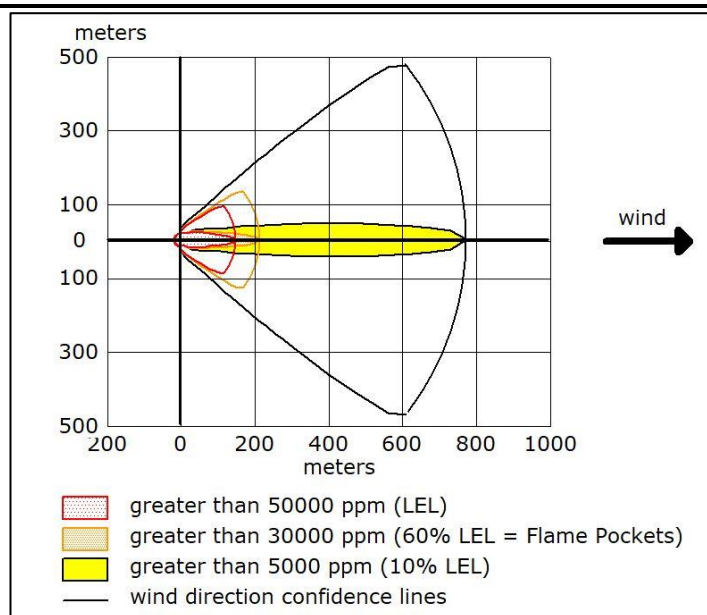
Threat Modelled: Flammable Area of Vapour Cloud

Model Run: Gaussian

Red : 77 meters --- (26,400 ppm = 60% LEL = Flame Pockets)

Yellow: 183 meters --- (4,400 ppm = 10% LEL)

Figure 6 Scenario IV: Risk Contour Map



THREAT ZONE:

Threat Modelled: Flammable Area of Vapour Cloud
 Model Run: Gaussian

Red : 148 meters --- (50000 ppm = LEL)

Orange : 214 meters --- (30000 ppm = 60% LEL = Flame Pockets)

Yellow: 774 meters --- (5000 ppm = 10% LEL).

The zone of flammable vapour cloud calculated for hypothetical natural gas release under risk scenarios discussed in the earlier sections have been presented in Table 11 below.

Table 11 Zone of Flammable Vapour Cloud-Natural Gas Release Scenarios

Release Type	Release Rate (kg/s)	Red -60% LEL (m)	Orange	Yellow -10% LEL (m)
Small	1	25		65
Medium	5	55		131
Large	10	77		183
Worst Case	310	148 (LEL)	214 (60% LEL)	774

Hence for a worst-case scenario the flammable vapour cloud zone/flame pockets' resulting from accidental release of natural gas due to blow out will be resulting in LEL concentration of 50,000 ppm at 148 m from source with the flammable gas concentration within this zone being 50,000 ppm i.e. LEL. For methane, the explosive limit ranges from 5% volume i.e. LEL to 15% by volume (which is the upper explosive limit). In the present worst-case scenario modelled, the explosive range falls within 57 to 148 m.

Based on the flammable vapour cloud concentration modelled for the worst case scenario (natural gas release due to blow out) an effort was made to establish the overpressure (blast force zone) that may result from delayed

ignition of vapour cloud generated from any such accidental release. For overpressure risk modelling using ALOHA a delayed ignition time of 5 minutes was considered of the vapour cloud mass. However the threat modelled revealed that Level of Concern (LOC) was never exceeded that may possibly lead to damage to property or life within the blast radius. The results have been provided in below.

Figure 7 Scenario III (Worst Case) – Overpressure Risk Modelling

Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Time of Ignition: 5 minutes after release begins
Type of Ignition: ignited by spark or flame
Level of Congestion: uncongested
Model Run: Gaussian
Explosive mass at time of ignition: 188 kilograms
Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)
Orange: LOC was never exceeded --- (3.5 psi = serious injury likely)
Yellow: LOC was never exceeded --- (1.0 psi = shatters glass)

The risk significance for the potential blow out scenario resulting from development drilling has been presented below. For calculating the risk significance, the likelihood ranking is “2” as the frequency analysis for blow outs incidents is computed at “ 3.2×10^{-4} ” whereas the consequence ranking has been identified to be as “4” given the worst-case scenario modelling (blast overpressure) indicates that the LOC was never exceeded leading to multiple fatalities (For criteria ranking please refer to *Tables 7.1 & 7.2*).

Risk Ranking – Blowout Natural Gas Release Overpressure (Worst Case Scenario)

Likelihood ranking	2	Consequence ranking	4
Risk Ranking & Significance = 8 i.e. “Low” i.e. Risk is Acceptable and are managed by well-established controls and routine processes/procedures. Implementation of additional controls can be considered, as may be required.			

Hydrocarbons Leaks Due to Loss of Containment While Drilling & Testing

The releases of hydrocarbons that may be isolated from reservoir fluids include gas releases in the mud return area during drilling. The consequences of gas releases are described in this section. ALOHA model has been used to model the releases from failure of the test separator.

Frequency Analysis

Review of the hydrocarbon release database (HCRD) of 2003 for **One North Sea Platform** indicates the process gas leak frequencies for large releases (>10 kg/s) to be about **6.0×10^{-3} per year**. The same frequency has been considered for potential release from leaks due to loss of containment while drilling.

Gas Releases during Drilling

a) Flash Fire

If gas is entrained in the mud then it could be released from the mud pits or shakers. The amount of gas returned is unlikely to be so great that a jet fire could occur, but the gas could build up into a flammable vapour cloud in the mud pit area. If the cloud then ignites it will result in a flash fire or vapour cloud explosion. Again, there is also the potential for a toxic cloud to be present if the release is during a period when sour crude is a possibility. The mud return typically contains around 50% water this means it cannot be ignited in liquid form so there is no danger of pool fires. Liquid mud fires are therefore not considered further.

The mud - gas separator can be other source that contains both flammable liquid and gas.

A well test separator rupture could result in release of gas when a gas cloud will form, initially located around the release point. If the release is ignited immediately then a fireball will be formed. If this cloud is not immediately ignited, then a vapour cloud will form, which will disperse with the wind and diluted as a result of air entrainment. The principal hazard arising from a cloud of dispersing flammable material is its subsequent (delayed) ignition, resulting in a flash fire. Large-scale experiments on the dispersion and ignition of flammable gas clouds show that ignition is unlikely when the average concentration is below the lower flammability limit (LFL).

As in the case for blow outs, an effort was made to establish the overpressure (blast force zone) that may result from delayed ignition of vapour cloud generated from any such accidental release. For overpressure risk modelling using ALOHA a delayed ignition time of 5 minutes was considered of the vapour cloud mass. However the threat modelled revealed that Level of Concern (LOC) was never exceeded that may possibly lead to damage to property or life within the blast radius. The results have been provided in *Figure 8* below.

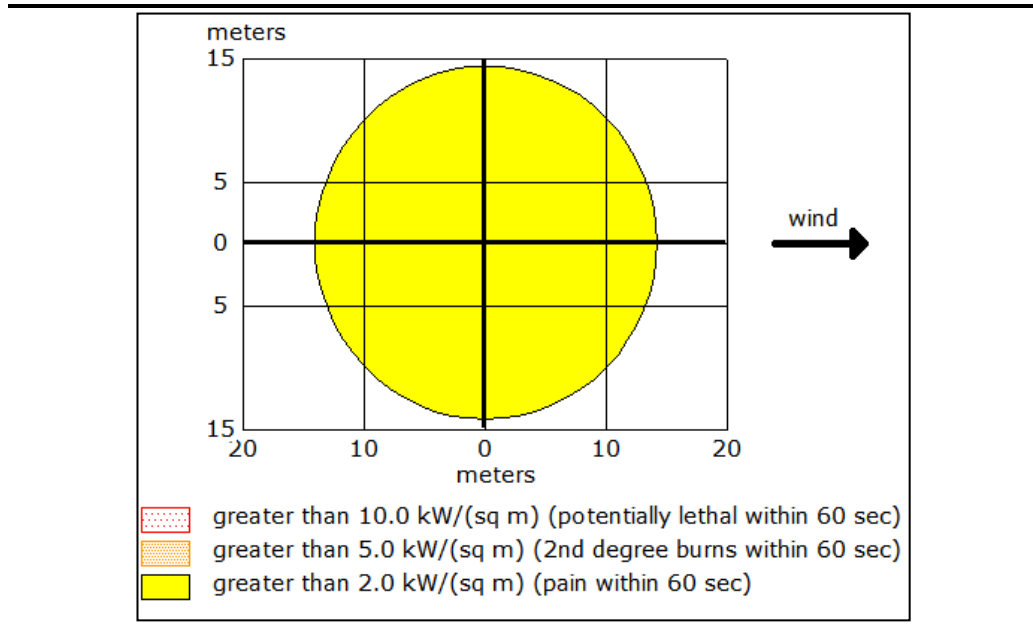
Figure 8 Overpressure Risk Modelling - Well Releases during drilling

Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: uncongested
Model Run: Gaussian
Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)
Orange: LOC was never exceeded --- (3.5 psi = serious injury likely)
Yellow: LOC was never exceeded --- (1.0 psi = shatters glass)

b) Jet Fire

The term jet fire is used to describe the flame produced due to the ignition of a continuous pressurised leakage from the pipe work. Combustion in a jet fire occurs in the form of a strong turbulent diffusion flame that is strongly influenced by the initial momentum of the release. Flame temperatures for typical jet flames vary from 1600°C for laminar diffusion flames to 2000°C for turbulent diffusion flames. The principal hazards from a jet fire are thermal radiation and the potential for significant knock-on effects, such as equipment failure due to impingement of the jet fire. The thermal radiation distances due to Jet Flame are shown in Figure 9 and Figure 10.

Figure 9 Thermal Radiation Distances of Jet Flame due to Leak of 25 mm size



THREAT ZONE:

Threat Modelled: Thermal radiation from jet fire

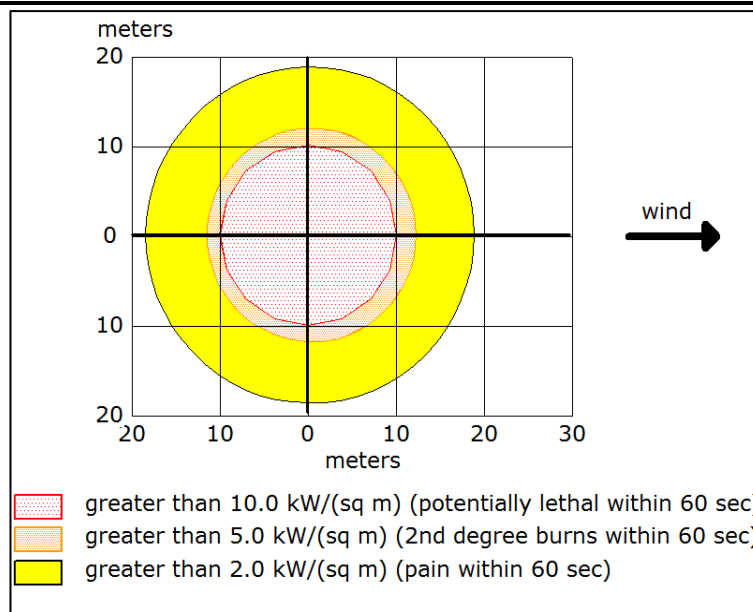
Model Run: Gaussian

Red: < 10 meters --- (10.0 kW/(sq. m) = potentially lethal within 60 sec)

Orange: < 10 meters --- (5.0 kW/(sq. m) = 2nd degree burns within 60 sec)

Yellow: 14 meters --- (2.0 kW/(sq. m) = pain within 60 sec)

Figure 10 Thermal Radiation Distances of Jet Flame due to Leak of 50 mm size



THREAT ZONE:

Threat Modelled: Thermal radiation from jet fire

Model Run: Gaussian

Red : 10 meters --- (10.0 kW/(sq. m) = potentially lethal within 60 sec)

Orange: 12 meters --- (5.0 kW/(sq. m) = 2nd degree burns within 60 sec)

Yellow: 19 meters --- (2.0 kW/(sq. m) = pain within 60 sec)

The zone of thermal radiation calculated for hypothetical release and ignition of natural gas during well testing have been presented in the Table 12.

Table 12 Thermal Radiation Zone -Natural Gas Release Scenario during Well Testing

Release Type	Red (kW/sqm)	Orange (kW/sqm)	Yellow (kW/sqm)
Leak of 25 mm size	<10	<10	14
Leak of 50 mm size	10	12	19

Hence for a worst case scenario (50 mm leak) the ignition of natural gas release will be resulting in generation of thermal radiation which will be lethal within a maximum radius of 10m within 1 minute of its occurrence.

The risk significance for the potential well release scenario resulting from development drilling has been presented below. For calculating the risk significance, the likelihood ranking is considered to be “3” as the frequency analysis for pipeline leak from jet fire is computed at “ 6.0×10^{-3} ” whereas the consequence ranking has been identified to be as “4” given the worst-case scenario modelling (blast overpressure)/jet fire indicates that the LOC was never exceeded leading to multiple fatalities (For criteria ranking please refer to **Tables 1 & 2**).

Risk Ranking – Jet Fire/Blast Overpressure from Well Releases (Worst Case Scenario)

Likelihood ranking	3	Consequence ranking	4
Risk Ranking & Significance = 12 i.e. "Medium" i.e. Risk is Tolerable and can be managed through adoption of necessary controls and technologies.			

Interconnecting Hydrocarbon Pipeline Network

As discussed in the project description section, a gas pipeline of 400 mm diameter and 17 km length would be laid connecting Jorajan OCS to OCS-3. Additionally assorted oil and gas pipelines 50 mm-300 mm in diameter would be laid in the Block with the total length of 40 kms. Some of the key hazard likely to be associated with same has been presented below

- Jet fires associated with pipework failures;
- Vapour cloud explosions; and
- Flash fires.

Each of these hazards has been described below.

Jet Fire

Jet fires result from ignited releases of pressurized flammable gas or superheated/pressurized liquid. The momentum of the release carries the material forward in a long plume entraining air to give a flammable mixture. Jet fires only occur where the natural gas is being handled under pressure or when handled in gas phase and the releases are unobstructed.

Flash Fire

Vapour clouds can be formed from the release of vapour of pressurized flammable material as well as from non-flashing liquid releases where vapour clouds can be formed from the evaporation of liquid pools or leakage/rupture of pressurized pipelines transporting flammable gas.

Where ignition of a release does not occur immediately, a vapour cloud is formed and moves away from the point of origin under the action of the wind. This drifting cloud may undergo delayed ignition if an ignition source is reached, resulting in a flash fire if the cloud ignites in an unconfined area or vapour cloud explosion (VCE) if within confined area.

Vapour Cloud Explosion

If the generation of heat in a fire involving a vapour-air mixture is accompanied by the generation of pressure then the resulting effect is a vapour cloud explosion (VCE). The amount of overpressure produced in a VCE is determined by the reactivity of the gas, the strength of the ignition source, the degree of confinement of the vapour cloud, the number of

obstacles in and around the cloud and the location of the point of ignition with respect to the escape path of the expanding gases.

However, in the case of the interconnecting gas pipeline network *jet fire* has been identified as the most probable hazard.

Pipeline Frequency Analysis

An effort has also been made to understand the primary failure frequencies of pressurised gas/oil to be transported through the interconnecting pipeline network. Based on the European Gas Pipeline Incident Data Group (EGIG) database the evolution of the primary failure frequencies over the entire period and for the last five years has been provided in Table 13.

Table 13 Primary Gas Pipeline Failure Frequency

Period	No. of Incidents	Total System Exposure (km.yr)	Primary failure frequency (1000 km.yr)
1970-2007	1173	3.15.10 ⁶	0.372
1970-2010	1249	3.55.10 ⁶	0.351
1970-2013	1309	3.98.10 ⁶	0.329
1970-2016	1366	4.41.10 ⁶	0.310
1970-2019	1411	4.84.10 ⁶	0.292
1980-2019	1050	4.36.10 ⁶	0.241
1990-2019	663	3.63.10 ⁶	0.183
2000-2019	388	2.64.10 ⁶	0.147
2010-2019	184	1.42.10 ⁶	0.129
2015-2019	90	0.71.10 ⁶	0.126

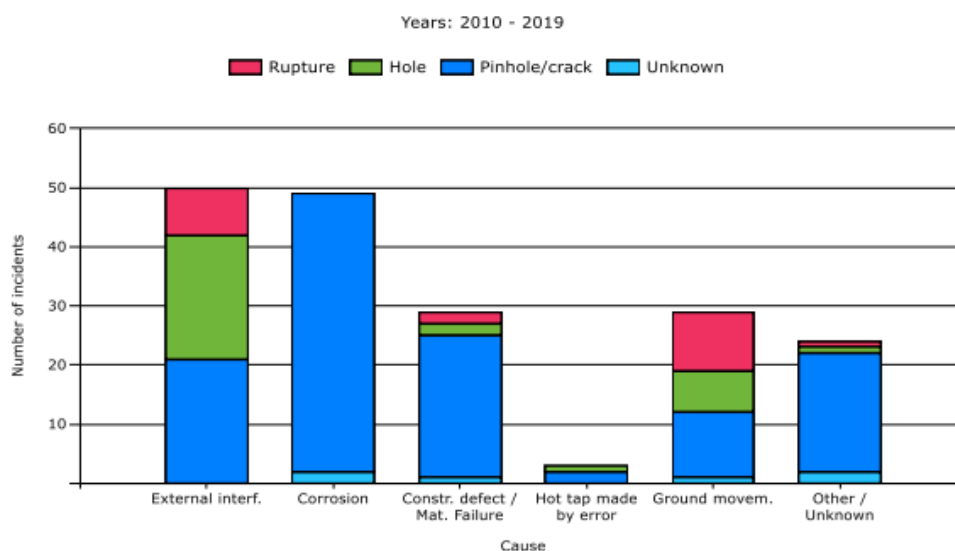
Source: 11th EGIG Report

As referred in the above table the overall failure frequency 0.29 per 1000 km. year (i.e. 2.9×10^{-4} per km. year) of the entire period (1970-2019) is slightly lower than the failure frequency of 0.31 per 1000 km. year reported in the 10th EGIG report (1970-2016). The failure frequency of the last 5 years (2015-2019) was found to be 0.13 per 1000 km.year, depicting an improved performance over the recent years.

Incident Causes

Gas pipeline failure incidents can be attributed to the following major causes viz. external interference, construction defects, corrosion (internal & external), ground movement and hot tap. The distribution of incidents with cause has been presented in Figure 11.

Figure 11 Number of Incident per Cause during 2010-2019



Source: 11th EGIG Report

The interpretation of the aforesaid figure indicated external interference as the major cause of pipeline failure followed by corrosion construction defects, ground movement (resulting from seismic disturbance, landslides, flood etc.) and other unknown reasons.

Review of the 11th EGIG report indicates that primary failure frequency varies with pipeline diameter, and the same has been presented in Table 14.

Table 14 Primary Failure Frequency based on Diameter Class (1970-2013)

Nominal Diameter (inch)	Primary failure frequency (per km.yr)		
	Pinhole/Crack	Hole	Rupture
diameter < 5"	4.45 X 10 ⁻⁴	2.68 X 10 ⁻⁴	1.33 X 10 ⁻⁴
5" ≤ diameter < 11"	2.80 X 10 ⁻⁴	1.97 X 10 ⁻⁴	6.40 X 10 ⁻⁵
11" ≤ diameter < 17"	1.27 X 10 ⁻⁴	0.98 X 10 ⁻⁴	4.10 X 10 ⁻⁵
17" ≤ diameter < 23"	1.02 X 10 ⁻⁴	5.00 X 10 ⁻⁵	3.40 X 10 ⁻⁵
23" ≤ diameter < 29"	8.50 X 10 ⁻⁵	2.70 X 10 ⁻⁵	1.20 X 10 ⁻⁵
29" ≤ diameter < 35"	2.30 X 10 ⁻⁵	5.00 X 10 ⁻⁶	1.40 X 10 ⁻⁵
35" ≤ diameter < 41"	2.30 X 10 ⁻⁵	8.00 X 10 ⁻⁶	3.00 X 10 ⁻⁶
41" ≤ diameter < 47"	7.00 X 10 ⁻⁶	-	-
diameter ≥ 47"	6.00 X 10 ⁻⁶	6.00 X 10 ⁻⁶	6.00 X 10 ⁻⁶

Source: 9th EGIG Report

The pipeline failure frequency viz. leaks or rupture for the natural gas pipeline has been computed based on the aforesaid table. Considering the trunk gas pipeline to be laid is likely to have a 400mm dia (15.74 inches) and assorted pipelines of diameters varying from 50mm (1.96 inches) to 300mm (11.81 inches), the failure frequency has been presented in Table 15.

Table 15 Interconnecting Pipeline - Failure Frequency

Sl. No	Pipeline Failure Case	EGIG Failure Frequency (per km.year)	Pipeline Dia mm [inches]	Avg. Pipeline Length (km)	Project Pipeline Failure Frequency (per year)	Frequency
1	Pipeline Rupture	1.33×10^{-4}	50 [2"]	10	1.33×10^{-3}	Occasional/Rare
2	Pipeline Leak	4.45×10^{-4}	50 [2"]	10	4.45×10^{-3}	Occasional/Rare
3	Pipeline Rupture	6.40×10^{-5}	152.4 [6"]	10	6.40×10^{-4}	Not Likely
4	Pipeline Leak	2.80×10^{-4}	152.4 [6"]	10	2.80×10^{-3}	Occasional/Rare
5	Pipeline Rupture	6.40×10^{-5}	200 [8"]	10	6.40×10^{-2}	Occasional/Rare
6	Pipeline Leak	2.80×10^{-4}	200 [8"]	10	2.80×10^{-3}	Occasional/Rare
7	Pipeline Rupture	4.10×10^{-5}	300 [12"]	10	4.10×10^{-4}	Not Likely
8	Pipeline Leak	1.27×10^{-4}	300 [12"]	10	1.27×10^{-3}	Occasional/Rare
9	Pipeline Rupture	4.10×10^{-5}	400 (16")	17	6.97×10^{-4}	Not Likely
10	Pipeline Leak	1.27×10^{-4}	400 (16")	17	2.15×10^{-3}	Occasional/Rare

Thus the probability of pipeline leak and rupture with respect to the interconnecting hydrocarbon pipeline network is identified to be as "Occasional/Rare" and "Not likely".

Pipeline Failure – Ignition Probability

The ignition probability of natural gas pipeline failure (rupture & leaks) with respect to the proposed expansion project is derived based on the following equations as provided in the ISEM/TD/2 standard

$$\left. \begin{aligned}
 P_{ign} &= 0.0555 + 0.0137pd^2; \text{ for } 0 \leq pd^2 \leq 57 \\
 \text{(For pipeline ruptures)} \\
 P_{ign} &= 0.81; \text{ for } pd^2 > 57
 \end{aligned} \right\}$$

$$\left. \begin{aligned}
 P_{ign} &= 0.0555 + 0.0137(0.5pd^2); \text{ for } 0 \leq 0.5pd^2 \leq 57 \\
 \text{(For pipeline leaks)} \\
 P_{ign} &= 0.81; \text{ for } 0.5pd^2 > 57
 \end{aligned} \right\}$$

Where:

- P_{ign}** = Probability of ignition
- p** = Pipeline operating pressure (bar)
- d** = Pipeline diameter (m)

The ignition and jet fire probability of natural gas release from a leak/rupture of interconnected pipeline network is calculated based on the above equations and presented in Table 16 below.

Table 16 Interconnecting Pipeline – Ignition & Jet Fire Probability

Sl. No	Pipeline Failure Case	Pipeline Dia (mm)	Project Pipeline Failure Frequency (per year)	Ignition Probability	Jet Fire Probability
1	Pipeline Rupture	50	1.33×10^{-3}	0.056	7.46×10^{-5}
2	Pipeline Leak	50	4.45×10^{-3}	0.055	2.48×10^{-4}
3	Pipeline Rupture	152.4	11.52×10^{-3}	0.060	7.02×10^{-4}
4	Pipeline Leak	152.4	5.04×10^{-2}	0.058	2.93×10^{-3}
5	Pipeline Rupture	200	11.52×10^{-3}	0.064	7.48×10^{-4}
6	Pipeline Leak	200	5.04×10^{-2}	0.060	3.03×10^{-3}
7	Pipeline Rupture	300	4.10×10^{-4}	0.076	3.14×10^{-5}
8	Pipeline Leak	300	1.27×10^{-3}	0.066	8.3×10^{-4}
9	Pipeline Rupture	400	6.97×10^{-4}	0.093	6.5×10^{-5}
10	Pipeline Leak	400	2.15×10^{-3}	0.074	1.6×10^{-4}

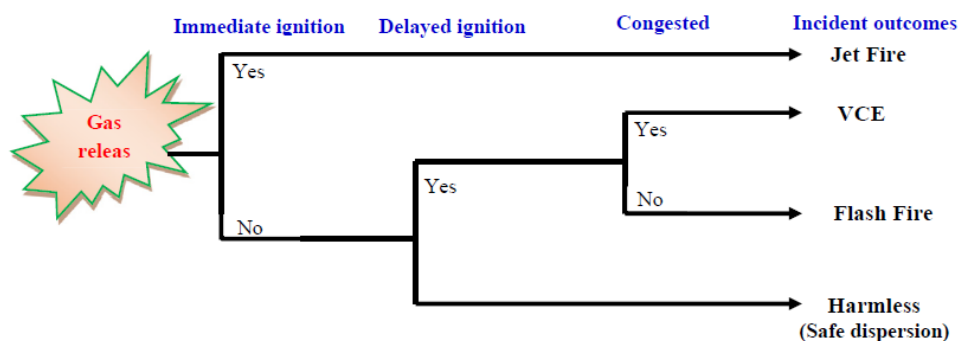
Hence from the above table it can be concluded that jet fire probability of natural gas that may be released from the trunk and assorted pipelines due to any accidental event is “*Not likely*”.

Consequence Analysis – Pipelines & GCS

Pipelines generally contains large inventories of oil or gas under high pressure; although accidental releases from them are remote they have the potential of catastrophic or major consequences if related risks are not adequately analysed or controlled. The consequences of possible pipeline failure is generally predicted based on the hypothetical failure scenario considered and defining parameters such as meteorological conditions (stability class), leak hole & rupture size and orientation, pipeline pressure & temperature, physicochemical properties of chemicals released etc.

In case of pipe rupture of highly flammable natural gas, an immediate ignition will cause a jet fire. Flash fires can result from the release of natural gas through the formation of a vapour cloud with delayed ignition and a fire burning through the cloud. A fire can then flash back to the source of the leak and result in a jet fire. Flash fires have the potential for offsite impact as the vapour clouds can travel considerable distances downwind of the source. Explosions can occur when a flammable gas cloud in a confined area is ignited; however where vapour cloud concentration of released material is lower than Lower Flammability Limit (LFL), consequently the occurrence of a VCE is highly unlikely. VCE, if occurs may result in overpressure effects that become more significant as the degree of confinement increases (Refer Figure 12). Therefore, in the present study, only the risks of jet fires for the below scenarios have been modelled and calculated.

Figure 12 Natural Gas Release – Potential Consequences



[Source: “Safety risk modelling and major accidents analysis of hydrogen and natural gas releases: A comprehensive risk analysis framework” - Iraj Mohammadfam, Esmail Zarei]

Based on the above discussion and frequency analysis as discussed in the earlier section, the following hypothetical risk scenarios (Refer Table 17) have been considered for consequence analysis of the interconnecting pipelines.

Table 17 Interconnecting Pipeline Risk Modelling Scenarios

Scenario	Source	Pipeline dia (mm)	Accident Scenario	Design Pressure (bar)	Ambient Temperature	Potential Risk
1	Pipeline	50	Complete rupture	17.23	24°C	Jet Fire
2	Pipeline	300	Leak of 75mm dia	17.23	24°C	Jet Fire
3	Pipeline	300	Complete rupture	17.23	24°C	Jet Fire
4	Pipeline	200	Leak of 50mm dia	17.23	24°C	Jet Fire
5	Pipeline	200	Complete Rupture	17.23	24°C	Jet Fire
6	Pipeline	152.4	Leak of 50mm dia	17.23	24°C	Jet Fire
7	Pipeline	152.4	Complete Rupture	17.23	24°C	Jet Fire
8	Pipeline	400	Leak of 100 mm dia	17.23	24°C	Jet Fire
9	Pipeline	400	Complete rupture	17.23	24°C	Jet Fire

The pipeline failure risk scenarios have been modeled using ALOHA and interpreted in terms of Thermal Radiation Level of Concern (LOC) encompassing the following threshold values (measured in kilowatts per square meter) for natural gas (comprising of ~95% methane¹) to create the default threat zones:

Red: 10 kW/ (sq. m) -- potentially lethal within 60 sec;

¹ https://www.naesb.org//pdf2/wgq_bps100605w2.pdf
<http://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=18&ved=0ahUKewjF7MiDtPRAhVCMi8KHd7aD6cQFghrMBE&url=http%3A%2F%2Fwww.springer.com%2Fcontent%2Fdocument%2Fdocument%2Fdownloaddocument%2F9781848828711-c1.pdf%3FSGWID%3D0-0-45-862344-p173918930&usg=AFQjCNEaJkfyKI3fRUdi6xiRYeW-FJb2A>

Orange: 5 kW/(sq. m) -- second-degree burns within 60 sec; and

Yellow: 2 kW/(sq. m) -- pain within 60 sec.

For vapour cloud explosion, the following threshold level of concern has been interpreted in terms of blast overpressure as specified below:

Red: 8.0 psi – destruction of buildings;

Orange: 3.5 psi – serious injury likely; and

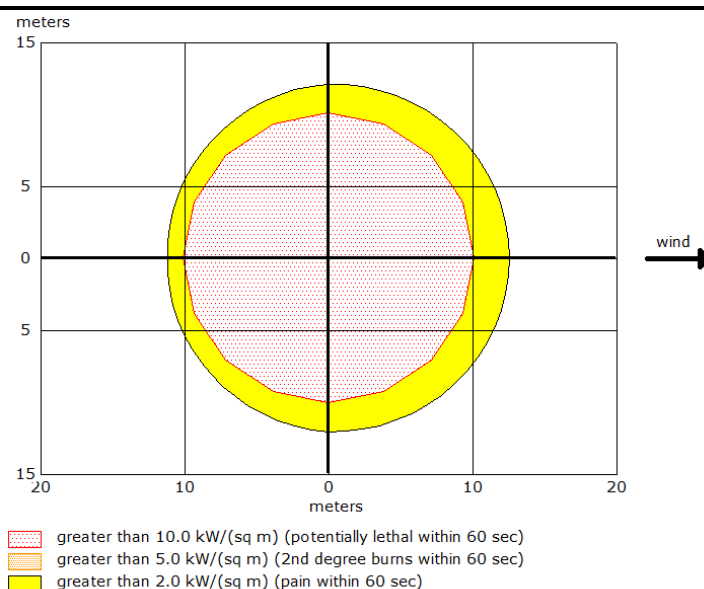
Yellow: 1.0 psi – shatters glass

The risk scenarios modelled for pipeline failure has been presented below:

Scenario 1: 50mm dia Pipeline Complete Rupture

The jet fire threat zone plot for release and ignition of natural gas from 50 mm dia pipeline rupture is represented in Figure 13.

Figure 13 Threat Zone Plot – 50mm dia pipeline complete rupture



Source: ALOHA

THREAT ZONE:

Threat Modelled: Thermal radiation from jet fire

Red : 10 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 10 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

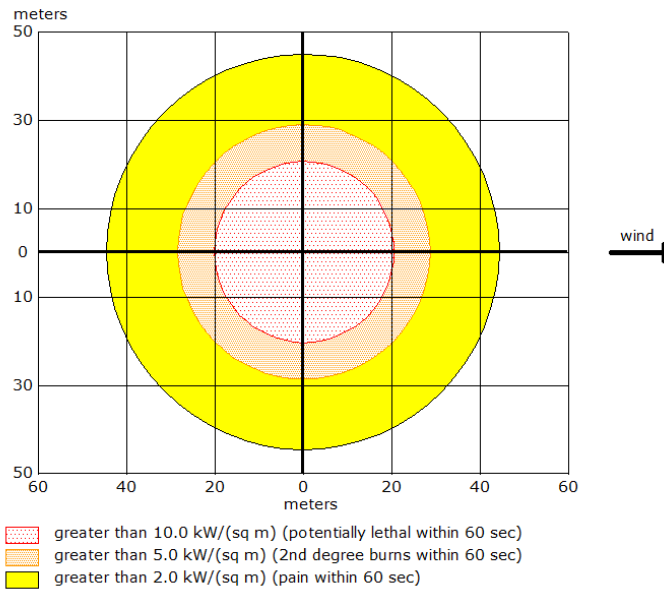
Yellow: 13 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of natural gas from the 50m dia pipeline rupture will be experienced to a maximum radial distance of 10m from the source with potential lethal effects within 1 minute.

Scenario 2: 300mm dia Pipeline Leak (75mm dia)

The jet fire threat zone plot for release and ignition of natural gas from 300mm dia pipeline leak of 75mm dia is represented in Figure 14.

Figure 14 Threat Zone Plot - 300mm dia pipeline leak (75mm dia)



Source: ALOHA

THREAT ZONE:

Threat Modelled: Thermal radiation from jet fire

Red : 21 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 29 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

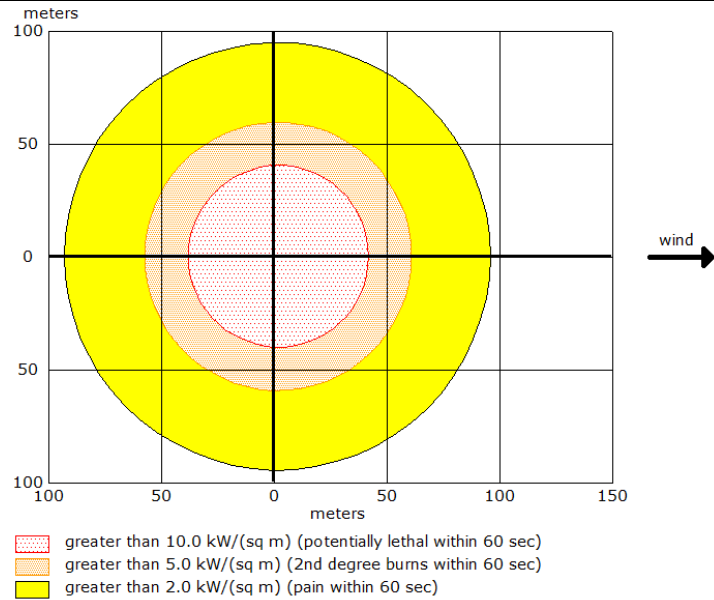
Yellow: 45 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of natural gas from 300m dia pipeline leak of 75mm dia will be experienced to a maximum radial distance of 21m from the source with potential lethal effects within 1 minute.

Scenario 3: 300mm dia Pipeline Rupture

The jet fire threat zone plot for release and ignition of natural gas from 300m dia pipeline rupture is represented in Figure 15.

Figure 15 Threat Zone Plot - 300mm dia pipeline rupture



Source: ALOHA

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : 42 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 61 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

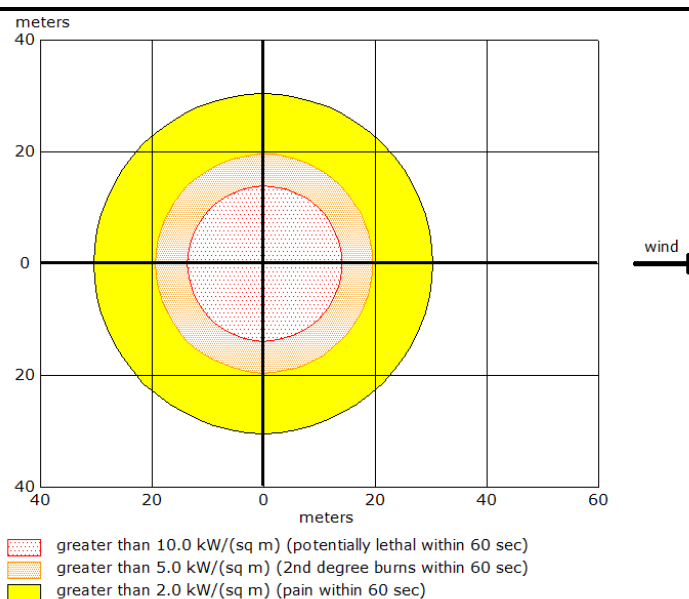
Yellow: 96 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of natural gas from 300mm dia pipeline rupture will be experienced to a maximum radial distance of 42m from the source with potential lethal effects within 1 minute.

Scenario 4: 200mm dia Pipeline Leak (50mm dia)

The jet fire threat zone plot for release and ignition of natural gas from 200mm dia pipeline leak of 50mm dia is represented in Figure 16.

Figure 16 Threat Zone Plot -200mm dia pipeline leak (50mm dia)



Source: ALOHA

THREAT ZONE:

Threat Modelled: Thermal radiation from jet fire

Red : 14 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 20 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

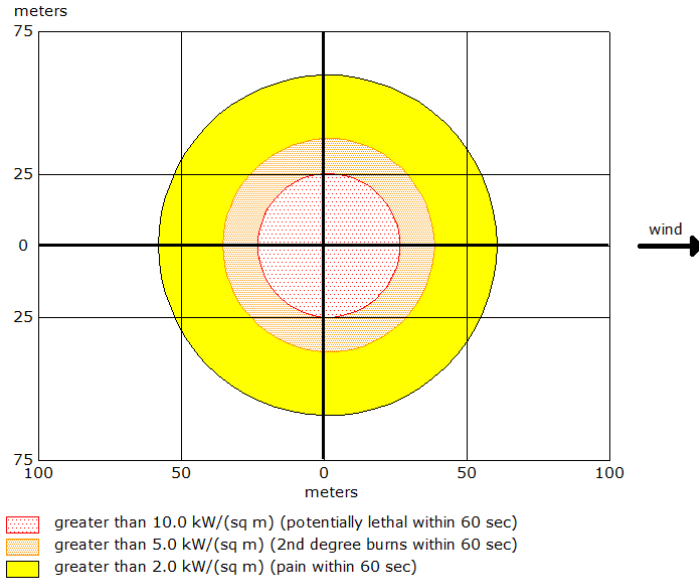
Yellow: 30 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of natural gas from 200mm dia pipeline leak of 50mm dia will be experienced to a maximum radial distance of 14m from the source with potential lethal effects within 1 minute.

Scenario 5: 200mm dia Pipeline Rupture

The jet fire threat zone plot for release and ignition of natural gas from 200mm dia pipeline rupture is represented in Figure 17.

Figure 17 Threat Zone Plot -200mm dia pipeline rupture



Source: ALOHA

THREAT ZONE:

Threat Modelled: Thermal radiation from jet fire

Red : 27 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 39 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

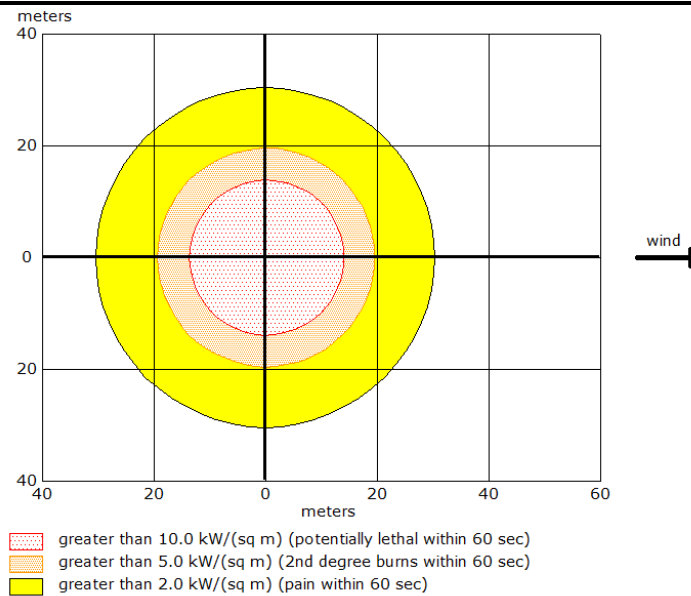
Yellow: 61 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of natural gas from 200mm dia pipeline rupture will be experienced to a maximum radial distance of 27m from the source with potential lethal effects within 1 minute.

Scenario 6: 152.4mm dia Pipeline Leak (50mm dia)

The jet fire threat zone plot for release and ignition of natural gas from 152.4mm dia pipeline leak of 50mm dia is represented in Figure 18.

Figure 18 Threat Zone Plot -152.4mm dia pipeline leak (50mm dia)



Source: ALOHA

THREAT ZONE:

Threat Modelled: Thermal radiation from jet fire

Red : 14 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 20 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

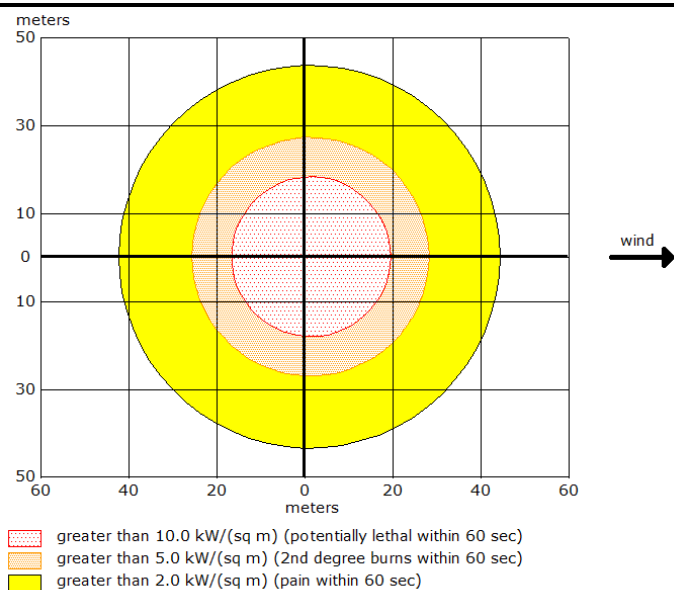
Yellow: 30 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of natural gas from 152.4mm dia pipeline leak of 50mm dia will be experienced to a maximum radial distance of 14m from the source with potential lethal effects within 1 minute.

Scenario 7: 152.4mm dia Pipeline Rupture

The jet fire threat zone plot for release and ignition of natural gas from 152.4m dia pipeline rupture is represented in Figure 19.

Figure 19 Threat Zone Plot - 152.4mm dia pipeline rupture



Source: ALOHA

THREAT ZONE:

Threat Modelled: Thermal radiation from jet fire

Red : 20 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 28 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

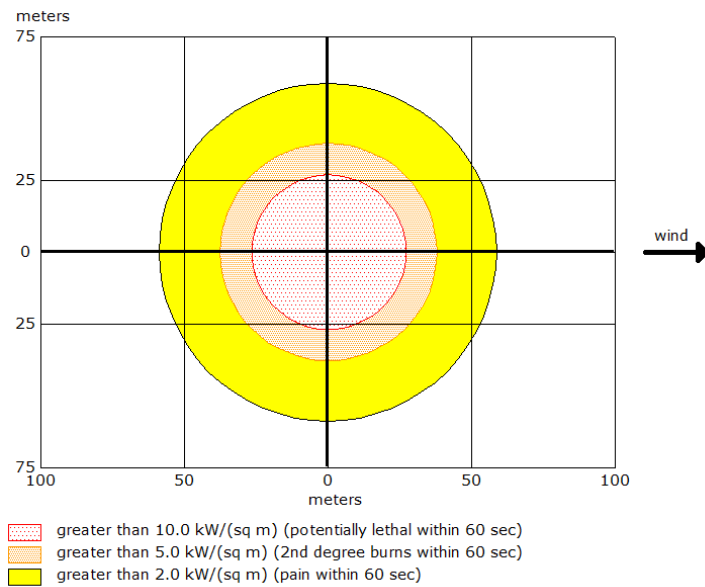
Yellow: 44 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of natural gas from 152.4mm dia pipeline rupture will be experienced to a maximum radial distance of 20m from the source with potential lethal effects within 1 minute.

Scenario 8: 400mm dia Pipeline Leak (100mm dia)

The jet fire threat zone plot for release and ignition of natural gas from 400mm dia pipeline leak of 100mm dia is represented in Figure 20 below.

Figure 20 Threat Zone Plot -400mm dia pipeline leak (100mm dia)



Source: ALOHA

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : 27 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 38 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

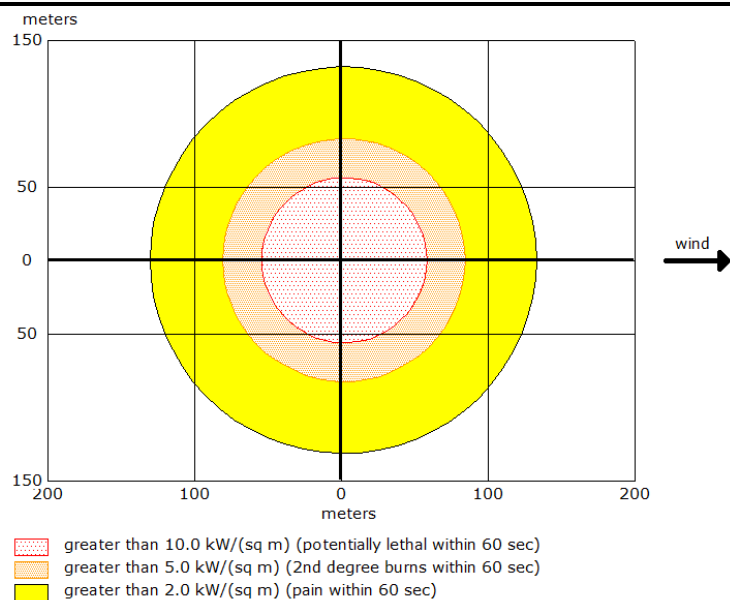
Yellow: 59 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of natural gas from 400mm dia pipeline leak of 100mm dia will be experienced to a maximum radial distance of 27m from the source with potential lethal effects within 1 minute.

Scenario 9: 400mm dia Pipeline Rupture

The jet fire threat zone plot for release and ignition of natural gas from 400m dia pipeline rupture is represented in Figure 21 below.

Figure 21 Threat Zone Plot - 400mm dia pipeline rupture



Source: ALOHA

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : 59 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 85 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

Yellow: 133 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of natural gas from 400mm dia pipeline rupture will be experienced to a maximum radial distance of 59m from the source with potential lethal effects within 1 minute.

For VCE modelled for catastrophic failure of interconnecting pipeline the LOC level was never exceeded

THREAT ZONE:

Threat Modeled: Overpressure (blast force) from vapour cloud explosion

Type of Ignition: ignited by spark or flame

Level of Congestion: uncongested

Model Run: Heavy Gas

Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)

Orange: LOC was never exceeded --- (3.5 psi = serious injury likely)

Yellow: LOC was never exceeded --- (1.0 psi = shatters glass)

For calculating the risk significance of natural gas pipeline, the likelihood ranking is considered to be "3" as the probability of pipeline rupture is computed to be $\sim 10^{-4}$ per year; whereas the consequence ranking has been identified to be as "4" as given for a worst case scenario (rupture) lethal effects is likely to be limited within a radial zone of ~ 123 m. Further as discussed in the earlier section, adequate number of gas leak and fire detection system of appropriate design will be provided for the interconnecting pipeline network to prevent for any major risk at an early stage of the incident.

Risk Ranking – Pipeline Rupture (Worst Case Scenario)

Likelihood ranking	3	Consequence ranking	4
Risk Ranking & Significance = 12 i.e. "Medium" i.e. Risk is Tolerable and can be managed through adoption of necessary controls and technologies.			

Hazardous Material Releases or Mishaps

Release of following materials are not considered as major accidents and therefore are not quantified in terms of frequency, consequence and the resulting risk.

- Diesel fuel;
- Lubricants;
- Mud Chemicals;
- Explosives.

Exposure to such hazards would be **occupational** rather than **major** hazards.

External Hazards

External hazards which may impair the safety of the rig include the following:

- Severe weather conditions;
- Earthquake or ground movement; and
- Security breaches.

Extreme weather conditions are primarily lightening, cyclones and high winds and heavy rains. They may result in injury (through slips trips of personnel) or equipment damage. Cyclones and high winds may damage the rig structure. There are potential hazards to workers from direct impact of the structure i.e. falling equipment and any subsequent hydrocarbon releases caused by equipment damage. However, no fatalities are expected from such conditions i.e. the risk to workers is low, providing:

- Reliable weather forecasts are available;
- Work or rig move is suspended if conditions become too severe;

- Design and operational limits of the rig structure are known and not exceeded.

Other natural hazards, such as earthquake are predominant in Assam region. The risk of external hazards causing blowouts has been considered in the frequency estimation of oil and gas blowouts in the earlier sections.

DISASTER MANAGEMENT PLAN

Disaster Management is a process or strategy that is implemented when any type of catastrophic event takes place. The Disaster Management Plan envisages the need for providing appropriate action so as to minimize loss of life/property and for restoration of normalcy within the minimum time in event of any emergency. Adequate manpower, training and infrastructure are required to achieve this.

The objectives of Disaster Management Plan are as follows:

- Rapid control and containment of the hazardous situation;
- Minimising the risk and impact of occurrence and its catastrophic effects;
- Effective rehabilitation of affected persons and prevention of damage to Property and environment;
- To render assistance to outside the factory.

The following important elements in the disaster management plan (DMP) are suggested to effectively achieve the objectives of emergency planning:

- Reliable and early detection of an emergency and careful response;
- The command, co-ordination, and response organization structure along with efficient trained personnel;
- The availability of resources for handling emergencies;
- Appropriate emergency response actions;
- Effective notification and communication facilities;
- Regular review and updating of the DMP;
- Proper training of the concerned personnel.

Emergency Identified

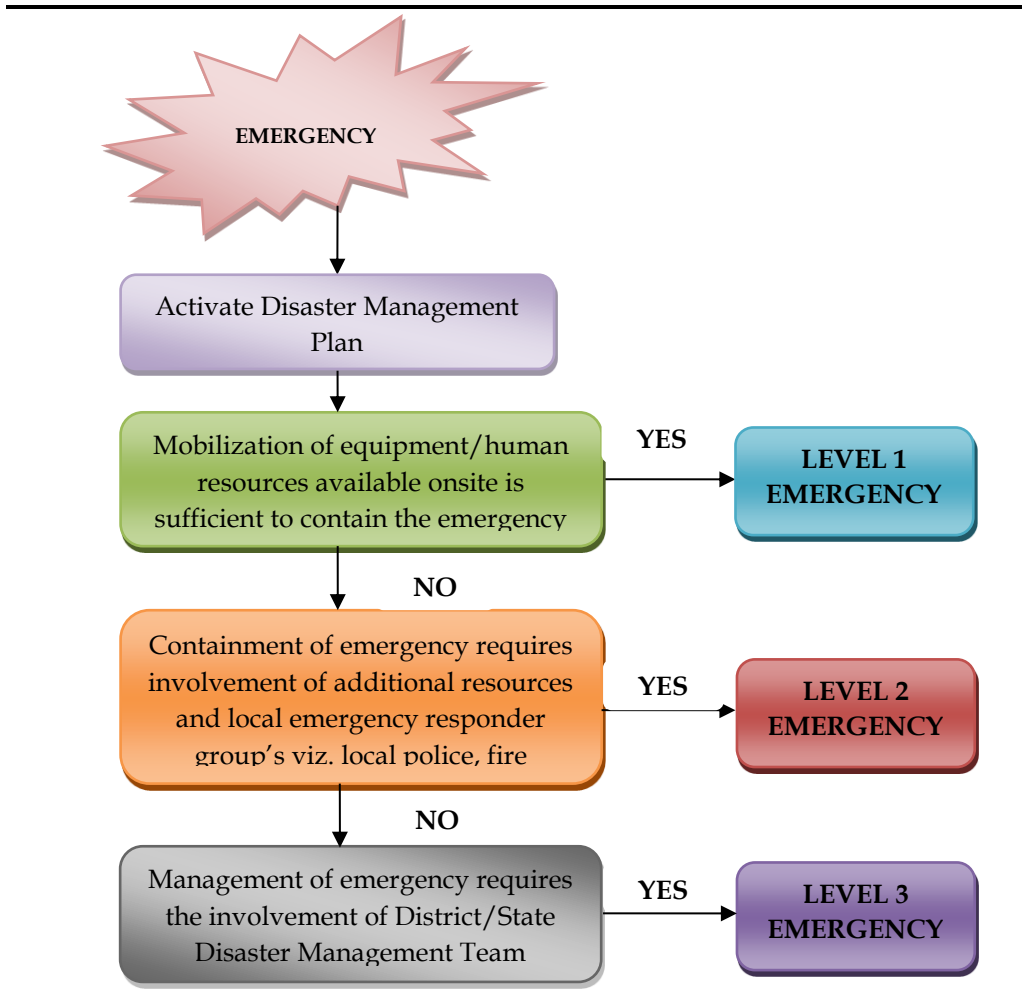
Emergencies that may arise:

- Such an occurrence may result in on-site implications like :
 - Fire or explosion;
 - Leakage of natural gas; and
 - Oil spillage and subsequent fire.
- Incidents having off-site implications can be:
 - Natural calamities like earthquake, cyclone, lightening, etc.
- Other incidents, which can also result in a disaster, are :
 - Agitation / forced entry by external group of people;
 - Sabotage.

Emergency Classification

Due consideration is given to the severity of potential emergency situation that may arise as a result of accident events as discussed in the **Risk Analysis (RA)** study. Not all emergency situations call for mobilization of same resources or emergency actions and therefore, the emergencies are classified into three levels depending on their severity and potential impact, so that appropriate emergency response procedures can be effectively implemented by the Emergency Response Team. The emergency levels/tiers defined with respect to this project based on their severity have been discussed in the subsequent sections with 'decision tree' for emergency classification being depicted in Figure 22.

Figure 22 Emergency Classification "Decision Tree"



The emergency situations have been classified in three categories depending upon their magnitude and consequences. Different types of emergencies that may arise at the project site can be broadly classified as:

Level 1 Emergency

The emergency situation arising in any section of one particular plant / area which is minor in nature, can be controlled within the affected section itself,

with the help of in-house resources available at any given point of time. The emergency control actions are limited to level 1 emergency organization only. But such emergency does not have the potential to cause serious injury or damage to property / environment and the domino effect to other section of the affected plant or nearby plants/ areas.

Level 2 Emergency

The emergency situation arising in one or more plants / areas which has the potential to cause serious injury or damage to property / environment within the affected plant or to the nearby plants / areas. This level of emergency situation will not affect surrounding community beyond the facility. But such emergency situation always warrants mobilizing the necessary resources available in-house and/or outsources to mitigate the emergency. The situation requires declaration of On – Site emergency.

Level 3 Emergency

The emergency is perceived to be a kind of situation arising out of an incident having potential threat to human lives and property not only within the facility but also in surrounding areas and environment. It may not be possible to control such situations with the resources available within OIL facility. The situation may demand prompt response of multiple emergency response groups as have been recognized under the off-site district disaster management plan of the concerned district(s).

Preventive and Mitigation Measures for Blow Outs

In case of a blowout Fire service team from OIL and other Mutual Aid partners will report at site and will start spraying water continuously from all directions to disperse the formation of any explosive mixture in and around the well head area and keep the well head area cool to avoid any fire incident. The Disaster Control Room will be activated and information will be sent to all Disaster Management Coordinators of Mutual Aid partners. The Oil and Natural Gas Corporation Ltd. (ONGCL), Crisis Management Team (CMT) will be contacted for their expertise and support to control the situation. International Blowout control agencies will also be engaged for blowout control as necessary.

Proposed action plan control blowout of hydrocarbon prior to fire incident

- Creation of facilities for pumping water to the blowing well.
- Infrastructure arrangement for capping the well.
- Pumping of sufficient water through the well annulus to make the flowing gas wet, thereby reducing gas condensate spread to the nearby areas.
- Adequate water spraying through Fire Service pumps and nozzles/ monitors.
- Taking all adequate HSE measures.
- Continuous gas testing for LEL level around the well plinth area.
- To clear all equipment's and debris from site.

- Arrange adequate drilling mud and pumping infrastructure
- To complete the fabrication of hydraulically operated mechanized structure (for moving/ placing Blow out Preventer (BOP)) at OIL's workshop, incorporating all the points identified in the mock drill.
- Place fabricated mechanized structure 20-25 m from the wellhead
- Move BOP to well mouth hydraulically. Splash water continuously
- Cap the well by placing BOP on the wellhead
- Subdue the well by pumping drilling mud immediately.

Proposed action plan to extinguish the fire in case of blowout

- Heat shielding of the working areas by suitable means.
- To clear all debris and damaged rig package & equipment from site.
- Arrange water and pumping infrastructure.
- Arrange adequate drilling mud and pumping infrastructure.
- Special tools and equipment's used for controlling well under fire to be mobilized from various sources nationally and internationally.
- Arranging to cap the well by placing BOP with the help of special tools (Athey wagon) after creating a continuous water umbrella.
- Subdue the well by pumping drilling mud & kill the well immediately.
- Bring the well under control.

Preventive Measures for Handling of Natural Gas

- Leak detection sensors to be located at areas prone to fire risk/ leakages;
- All safety and firefighting requirements as per OISD norms to be put in place;
- High temperature and high pressure alarm with auto-activation of water sprinklers as well as safety relief valve to be provided;
- Flame proof electrical fittings to be provided for the installation;
- Periodical training/awareness to be given to work force at the project site to handle any emergency situation;
- Periodic mock drills to be conducted so as to check the alertness and efficiency and corresponding records to be maintained;
- Signboards including emergency phone numbers and 'no smoking' signs should be installed at all appropriate locations;
- Plant shall have adequate communication system;
- Pipeline route/equipment should be provided with smoke / fire detection and alarm system. Fire alarm and firefighting facility commensurate with the storage should be provided at the unloading point;
- 'No smoking zone' to be declared at all fire prone areas. Non sparking tools should be used for any maintenance; and
- Wind socks to be installed to check the wind direction at the time of accident and accordingly persons may be diverted towards opposite direction of wind.

Preventive Measures for Interconnecting Pipeline Risk Management

- Design all pipes and vessels to cope with maximum expected pressure;
- Install pressure transmitters that remotely monitor high- and low-pressure alarms;
- Design equipment to withstand considerable heat load;
- Conduct regular patrols and inspections of pipeline easements;
- Fit pumps with automatic pump shutdown or other safety devices;
- Minimise enclosed spaces where flammable gas may accumulate;
- Where necessary, automate emergency shutdown systems at production facilities;
- Consider installing flow and pressure instrumentation to transmit upset conditions and plant shutdown valves status;
- Install fire and gas detection systems;
- Implement security controls;
- Install emergency shutdown buttons on each production facility;
- Bury gathering lines at a minimum depth of 600 mm and where above ground, maintain a clear area;
- Implement management of change processes; and
- Conduct pressure testing and inspection of equipment and pipelines.

Preventing Fire and Explosion Hazards

- Proper marking to be made for identification of locations of flammable storages;
- Provision of secondary containment system for all fuel and lubricating oil storages;
- Provision of fire and smoke detectors at potential sources of fire and smoke;
- Storing flammables away from ignition sources and oxidizing materials;
- Providing specific worker training in handling of flammable materials, and in fire prevention or suppression;
- Equipping facilities with fire detectors, alarm systems, and fire-fighting equipment;
- Fire and emergency alarm systems that are both audible and visible;
- For safety of people the building, regulations concerning fire safety to be followed. Some of the requirements include:
 - Installation of fire extinguishers;
 - Provision of water hydrants in operative condition;
 - Emergency exit;
 - Proper labelling of exit and place of fire protective system installation;
 - Conducting mock drills;
 - Trained personnel to use fire control systems.

General Health and Safety

- The facility will adopt a total safety control system, which aims to prevent the probable accidents such as fire accidents or chemical spills.

- Fire fighting system, such as sprinklers system, portable extinguishers (such as CO₂) and automated fire extinguishers shall be provided at strategic locations with a clear labelling of the extinguisher so the type of the extinguisher is easily identifiable. Also a main hydrant around the buildings will be available. On all floors an automated fire detection system will be in place.
- The site operations manager will take steps to train all emergency team members and shall draw up an action plan and identify members. The appointed emergency controller shall act as the in-charge at the site of the incident to control the entire operation.
- The staff shall be trained for first-aid and firefighting procedures. The rescue team shall support the first-aid and firefighting team.
- A first-aid medical centre will be onsite to stabilise the accident victim. The emergency team will make contact with a nearby hospital for further care, if required.
- A training and rehearsal of the emergency response by emergency team members and personnel on site will be done regularly.
- A safe assembly area will be identified and evacuation of the premises will be practised regularly through mock drills.
- In case an emergency is being declared, the situation shall be reported to the authorities such as local police, the chief inspector of factories and the state pollution control board as per rules and regulation of law of the land.
- Safety manual for storage and handling of Hazardous chemicals shall be prepared.
- All the personnel at the site shall be made aware about the hazardous substance stored and risk associated with them.
- Personnel engaged in handling of hazardous chemicals shall be trained to respond in an unlikely event of emergencies.
- A written process safety information document shall be compiled for general use and summary of it shall be circulated to concerned personnel.
- MSDS shall be made available and displayed at prominent places in the facility. The document compilation shall include an assessment of the hazards presented including (i) toxicity information (ii) permissible exposure limits. (iii) Physical data (iv) thermal and chemical stability data (v) reactivity data (vi) corrosivity data (vii) safe procedures in process.
- Safe work practices shall be developed to provide for the control of hazards during operation and maintenance
- In the material storage area, hazardous materials shall be stored based on their compatibility characteristics.
- Near miss and accident reporting system shall be followed and corrective measures shall be taken to avoid / minimize near miss incidents.
- Safety measures in the form of DO and Don't Do shall be displayed at strategic locations.
- Safety audits shall be conducted regularly.
- Firefighting system shall be tested periodically for proper functioning.
- All hydrants, monitors and valves shall be visually inspected every month.
- Disaster Management Plan shall be prepared and available with concerned personnel department.

Personal Protective Equipment

In certain circumstances, personal protection of the individual maybe required as a supplement to other preventive action. It should not be regarded as a substitute for other control measures and must only be used in conjunction with substitution and elimination measures. PPEs must be appropriately selected individually fitted and workers trained in their correct use and maintenance. PPEs must be regularly checked and maintained to ensure that the worker is being protected.

First Aid

First aid procedures and facilities relevant to the needs of the particular workforce should be laid down and provided in consultation with an occupational physician or other health professional.

Health assessment should form a part of a comprehensive occupational health and safety strategy. Where employees have to undergo health assessment, there should be adequate consultation prior to the introduction of such program. Medical records should be kept confidential. Site should be able to relate employee health and illness data to exposure levels in the workplace.

ANNEXURE 18

Blowout Management Plan

Blowout Management Plan

Blow out Preventive Measures

In view of the recent blowout OIL have taken the following measures, which will help in preventing recurrence of such incidents.

1. **Standard Operating Procedures:** Oil India has been following Good Petroleum Industry Practices and has Standard Operating Procedures for its activities with respect to all operations directly or indirectly related to Drilling, Workover, Production of oil & gas including maintenance, Logging or any other related services. The Blowout incident at well Baghjan-5 has necessitated a review of the existing SOPs and also add relevant ones for further improvement and operational excellence. The Standard Operating Procedures (SOPs) for various activities in the oil & gas installations as well as for other service departments in Oil India Limited have been reviewed (over 1000 activities). All SOPs will be reviewed after every 2 years. However, in case of change or upgradation in equipment/ system or adoption of any new system, the relevant SOP will be reviewed/ added as and when required.

A programme will also be implemented for periodic visits of various levels of senior officials to different work centres with proper checklists so that these points are checked during each visit and proper records of such visits are maintained for periodic review by the HoDs, Group Heads, RCE and concerned Directors.

2. **Structural change:** OIL had earlier shifted to an asset based structure for the Main Producing Area under Fields Headquarter with an objective of increasing production through focussed attention to the matured acreages covered by the Mining Leases in Assam and Arunachal Pradesh. The Asset based structure has proved to be effective and the G&R teams have now been reorganised in alignment with the Assets to provide focused support. However, it is perceived that there is scope for improvement in the structure especially in areas of drilling and workover operations. The present processes seem to lead to a blurred state of responsibilities and a lack of single point control. Thus the current system requires a complete overhaul and the systems, processes and reporting hierarchy require an immediate change.

With the above in view certain structural changes are being brought in in the following areas:

- a. Work flow for custody transfer of well in different phases of its lifecycle.
- b. Restructuring of Organogram for Workover activities in Main Producing Area (MPA)

Under the above initiative, WO Section, which is currently a part of Drilling Services and reports to Director (E&D) will be brought under Director (Operations) along with the rig resources, allied services and personnel on 'as is where is basis'. This will ensure more job focus and single point responsibility in work-over operations.

3. **Mines Structure**: The above will also necessitate restructuring of the Mines Structure. Accordingly actions will be taken to reassign Mines Owner, Mines Agent, Deemed Agent, Mines Manager etc., in line with the new operational structure at Fields Headquarter.
4. **Crisis Management Team (CMT)**: Oil India currently has a CMT. However, in effect this department has not been empowered in its true sense. The department will now be strengthened with adequate numbers of engineers and staff. All CMT persons will be trained up in relevant areas (International Well Control Forum-IWCF /International Association of Drilling Contractors- IADC etc.) and will also be engaged in routine maintenance activities of heavy duty equipment. Frequency of mock drills will be increased to keep the members in full readiness at all times.
5. **Safety Audits**: Presently OIL has a robust system of safety audits with following audits carried out in every Drilling/ Workover location:
 - i. Pre- Spud in audits in Drilling Rigs before starting the operation.
 - ii. Pre-Workover audits in Workover Rigs before starting the operation.
 - iii. Surprise Safety audit during Drilling & Workover operations
 - iv. Multidisciplinary Audit in all operating drilling rigs and workover rigs annually during Internal Safety Week observance.

Environment Management in case of blowout

Efforts will be undertaken by OIL by engaging its own resources and hired services from organizations of national repute to minimize impacts on the environment in case of a blowout. The following organizations will be involved for the purpose mentioned above, apart from the District Administration.

- i. Accredited Environment Management Consultants for Impact Assessment study
- ii. National Level Govt. Institutes for Bioremediation
- iii. National Agricultural University
- iv. CSIR Institute for subsidence study

An oil spill due to Well Blow out is possible during Drilling activities when wells are drilled to meet exploration, development or production requirement. Well Blow out is also possible during any subsequent "Well Intervention" of existing wells for Work - Over activities. In the event of an unfortunate well blow out, the situation will call for the immediate services of Well Control specialists. But, adherence to established drilling procedures which includes

proper use of BOPs of rated pressures will adequately control the oil spill risk due to well blow outs.

The actions planned for execution by OIL to mitigate the impacts on the environment is briefed below.

(A) Environmental Assessment: A National Level Accredited environmental management consultant will be engaged to assess the site surroundings and affected area around the well location based on site observations, environmental and ecological monitoring and stakeholder consultations.

(B) Spillage cleaning and Bio-remediation: Bio-remediation is a process of recuperating the original properties of oil contaminated soil and water by treating with oil consuming bacteria. A reputed National Level Institute will be engaged with the objective to recuperate the original properties of whatever soil and water are contaminated with oil spillage incident.

(C) Picking up of spilled oil manually and by turbo pump: After the incident of blowout, several bunds will be constructed around the area of blowout to arrest the spilled oil flowing to the nearby water bodies. The oil arrested inside the bundhs will be picked up by manual efforts in drums and transferred to nearest production facility of OIL. Turbo pumps driven by water jet will also be used for lifting spilled oil.

Following Steps will be taken to collect the oil:

1. Using Oil Booms: The use of oil booms is a very simple and popular method of controlling oil spills. Equipment called containment booms acts like a fence to prevent the oil from further spreading or floating away. Booms float on the water surface and have three parts -

- A 'freeboard' is the part that rises above the water surface, containing the oil and preventing it from splashing over the top
- A 'skirt' is placed below the surface and keeps the oil from being squeezed under the booms and escaping
- A kind of cable or chain that connects the parts to strengthen and stabilize the boom. Connected sections of the boom are placed around the area of the oil spill until it is totally surrounded and contained.

2. Using Sorbents: Sorbents are materials that soak up liquids by either absorption (pulling in through pores) or adsorption (forming a layer on the surface). Both these properties make the process of clean-up much easier. Materials commonly used as oil sorbents are hay, peat moss, straw or vermiculite.

3. Using Dispersants: When the spilled oil cannot be contained by using booms, the only option left is to accelerate the disintegration of oil. Dispersal agents, such as Corexit 9500, are chemicals that are sprayed upon the spill with the help of boats, which aid the natural breakdown of oil components.

They allow the oil to chemically bond with water by increasing the surface area of each molecule. This ensures that the slick does not travel over the surface of the water, and is easier to degrade by microbes

4. Using Manual Labour: The method requires hand-held tools and manual labour to clean up the contaminants. It involves the use of manual means like hands, rakes, shovels etc. to clean the surface oil and oily debris and place them in special containers to be removed from the spilled area.

(D) Assessment of Environmental contamination: This will involve monitoring of air, soil, groundwater, surface water, sediment to detect impacts due to hydrocarbon contamination.

(E) Assessment of impact/ damage to the biodiversity: An assessment of biodiversity including the flora & wildlife in the affected area caused due to the blowout & fire. Competent authority of experts will assess damage to the Crops/Tree/Plants (Paddy/tea/Fruit/Vegetation) in the area likely to be affected by the blow out and subsequent fire

(F) Assessment of Health Hazard to Public: An assessment of health hazard to public in the affected area caused due to the blowout & fire.

(G) Damage Assessment for Compensation: The District Administration will constitute committees to assess the damage caused to the crops, livestock, houses, fishery etc. as per the guidelines of District Disaster Management Manual.

(H) Assessment of Vibration: CSIR- North East Institute of Science and Technology (NEIST) will be requested to assess alleged vibration of the locality.

Additional mitigation measures to be adopted by OIL

Recommendations provided by Director General of Mine Safety (DGMS) with respect to safety precautions will be undertaken in respect of any Workover Oil/Gas well in operation by OIL for to prevent the chances of accident in an OIL facility.

1. It shall be ensured that person(s) deployed in the workover area within 30m from any tank, separator, oil well, oil/gas manifold at the installation including in Zone -2 hazardous area, do not carry/possess mobile phones, any electronic device, cigar, cigarette, biri/other smoking apparatus or any match or kind which is capable of producing a light, flame or spark, excepting intrinsically safe apparatuses or such devices which are housed in a flame proof enclosure.
2. Before employing any person at the installation, it shall be ensured that such persons have undergone adequate and appropriate training under the Mines Vocational Training Rules, 1966 on safe conduct of various operations. Such persons may also be imparted requisite training on behavioural safety.
3. It shall be ensured that no person is permitted to enter into any place in the workover area which is likely to contain dangerous levels of hydrocarbon gases,

without wearing suitable fire-proof whole-body vests/jackets, to protect from sudden fire.

4. Whenever any operation connected to the conduct of workover are carried out, continuous presence of an official/Installation Manager shall be ensured at site for the purpose of proper management, control, supervision and direction of all workover operations.
5. Before commencement of operation at the installation, it shall be ensured by the Manager that a thorough Job Safety Analysis is carried out and various attendant issues arising thereof are addressed in accordance with law.
6. There shall be provided a system for effective handling, conduit and/or safe disposal of hydrocarbon gases through a properly constructed and maintained flare stack, thereby preventing accumulation and discharge into atmosphere.
7. A system of continuous monitoring and detection for hydrocarbon gases at all pre-defined locations by the Manager for the purpose, shall be provided in addition to monitoring by portable spot gas detection systems on hourly basis or at shorter intervals as may be decided by the Manager. A record of such monitoring/detection by portable spot gas detection systems shall be kept in a register kept for the purpose and shall be signed and dated by the person making the measurement. In case of the continuous monitoring and detection system, the measured readings may be kept in non-editable electronic form.
8. It shall be ensured that suitable protective systems such as Automatic Fire Detection and Suppression System (AFDSS), engine coolant temperature sensors, engine oil pressure gauge, over-heating tripping system and exhaust manifold & turbo charger guards, are provided and maintained on every internal-combustion (IC) engine. It shall also be ensured that the exhaust of every IC engine including exhaust pipe, muffler/silencer, are adequately insulated/protected to prevent contact with inflammable fluids.
9. It shall be ensured that every Draw Works is provided with a Fail-Safe braking system so as to get automatically applied in case of any pneumatic/hydraulic component failure.
10. It shall be ensured that equipment maintenance shall be carried out as per the procedure and schedule as per OEM guidelines/recommendations.
11. It shall be ensured that the entire workover area is kept under effective CCTV surveillance to monitor all operations closely.
12. Care shall be taken to ensuring that various SOPs made in connection with workover operations shall be in accordance with OMR 2017 and relevant OISD guidelines issued from time to time.

(Source: DGMS Technical Circular No. 01 of 2019)

Testing and maintenance of BOP in line with the OISD Guidelines (OISD-GDN-182) will be followed by OIL for safe operations at a drill site. The guidelines in this respect are provided below;

a. Function Test

- i. Blowout preventer function test should be performed on each round trip (but not more than once per day) or once a week whichever is earlier.
- ii. The test BOP pipe ram should be conducted when the production string is inside casing.
- iii. Pipe ram preventers should be function tested and closing time should be recorded.
- iv. Blind/Shear ram should be operated for function test while string is out of hole.
- v. All the tests results & problems observed during testing and any actions taken to remedy the problem should be documented

b. Pressure Testing

- i. All blowout prevention components that may be exposed to well pressure should be tested first to a low pressure of 200 to 300 psi and then to a high pressure i.e. at the rated working pressure of BOP or to the rated working pressure of the wellhead on which BOP is installed on, whichever is lower. When performing the low pressure test, do not apply a higher pressure and bleed down to the low test pressure. The higher pressure could initiate a seal that may continue to seal after the pressure is lowered and therefore misrepresenting a low pressure condition.
- ii. The initial high pressure test on components that could be exposed to well pressure (BOP stack) should be to the rated working pressure of the ram BOPs or to the rated working pressure of the wellhead that the stack is installed on, whichever is lower. Initial pressure tests are defined as those tests that should be performed on location before the well is spudded or before the equipment is put into operational service.
- iii. Each low pressure & high pressure tests must hold required pressure for 5 minutes.
- iv. There may be instances when the available BOP stack and / or the wellhead have higher working pressures than are required for the specific well bore conditions due to equipment availability. Special conditions such as these should be covered in the site-specific well control pressure test program.
- v. If the equipment does not hold the required pressure during a test , remedy the problem and retest the effected component
- vi. Test BOP using cup tester or test plug or tubing hanger.
- vii. Clear water should be used as test fluid.
- viii. All pressure tests on well control equipment should be conducted at least
 - Immediately upon installation.
 - After the disconnection or repair of any pressure containment seal in BOP but limited to the affected component.
 - Not exceeding 21 days
- ix. All the tests results & problems observed during testing and any actions taken to remedy the problem should be documented.

c. BOP drills

- i. BOP drills should be conducted at unschedule times when operations and hole conditions permit.
- ii. Drills must be conducted weekly (subject to BOP is installed on wellhead) to familiarize all personnel engaged in well completion /workover operations with appropriate safety measures.
- iii. All Crew members shall be instructed in the operation of BOP system and their responsibility in the event of Blow out
- iv. Total time taken to complete the drill should not be more than 2 minutes. The deficiencies/ delay in response be discussed for further improvement.

The drills should be documented in DPR.

