RISK ASSESSEMENT STUDY OF AUGMENTATION OF KOYALI-SANGANER PIPELINE

Submitted By: -

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PIPELINES DIVISION

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CHAPTER-1: EXECUTIVE SUMMARY

1.1 Introduction

The entire demand for petroleum products of North Gujarat and Rajasthan is currently met from Koyali refinery through Koyali-Sanganer Pipeline (KSPL). In the absence of any alternative means of supply, product placement at these locations gets severely affected in event of shutdown of Koyali refinery, thereby necessitating supply from other sources through un-economical modes. To address this problem new pumping units at Kandla have been approved, which involves transportation of products received coastally from Kandla till Viramgam only, while further transportation and delivery to Tap-off-Points (ToP) at Sidhpur, Salawas, Chittaurgarh and Jaipur will be done through KSPL after its augmentation.

Also, considering the expansion of PNC and additional availability of Naphtha from other units of Panipat refinery, the annual additional requirement of Naphtha is around 800 TMT. This requirement of naphtha is to be met through tank wagons through rail movement from Koyali to Panipat. Considering the volume to be transported and the inherent advantage of pipeline over other modes viz. safety, reliability, less energy consumption, environment-friendliness etc, it is prudent to transport Naphtha through Koyali Sanganer Pipeline (KSPL) upto Sanganer and from Sanaganer, IOCL proposes to lay a new 340 kms pipeline (Jaipur - Panipat Pipeline). The transportation of Naphtha also necessitates augmentation of KSPL.

In KSPL augmentation project the capacity would be augmented from existing 4.6 MMTPA to 6 MMTPA with use of DRA (Drag reducing Agent).

Salient features of the Augmentation of Koyali-Sanganer pipeline are listed below:

- Replacement of 1 existing motor driven MLPU (Main Line Pumping Unit) at Koyali with new MLPU of adequate capacity.
- Replacement of two existing mainline pumps at Koyali with new pumps of adequate capacity.
- Installation of 3 (2+1) motor driven MLPU's of adequate capacity at Viramgam for Pumping in Viramgam-Sidhpur section.
- Replacement of all existing engine/motor driven MLPU's at Sidhpur and Kot with new MLPU's of adequate capacity.
- 1 LBT of 10,000 KL nominal capacity at Kot.

All the existing facilities of pumping station like fire fighting, electrical system, Pump house, Pipeline etc. would comply with national, international standards and M.B. Lal committee recommendations.

This document is prepared by Mantec Consultants Pvt. Ltd. for Risk Assessment (RA) of augmentation of Koyali-Sanganer Pipeline to identify the key hazards and risks. By conducting this type of RA, it should be emphasized that the focus is on the major, worst-case, hazards and impacts from surrounding area of these units, essentially in order to priorities the off-site risks and potential impacts to the public.

1.2 Consequence Analysis

Consequence analysis involves the application of the mathematical, analytical and computer models (PHAST software) for calculation of the effects and damages subsequent to a hydrocarbon/toxic release accident.

PHAST (Process Hazard Analysis Software Tools) software developed by DNV GL (A Risk Management Company) is used for risk assessment studies involving flammable and toxic hazards where individual and societal risks are also to be identified. It enables the user to assess the physical effects of accidental releases of toxic or flammable chemicals.

PHAST v7.11 is used for consequence calculations and PHAST Risk Micro v6.7 is used for risk calculations for KSPL Aug Project. It contains a series of up to date models that allow detailed modeling and quantitative assessment of release rate pool evaporation, atmospheric dispersion, vapour cloud explosion, combustion, heat radiation effects from fires etc., The software is developed based on the hazard model given in TNO (as the basis of Yellow Book) models.

PHAST is the industry standard tool for Process Hazard Analysis (PHA). It is used to estimate, understand and visualize the effects from loss of containment scenarios. Applications of PHAST include-

- Plant layout
- Inventory planning
- Pollution control
- Providing input to major accident prevention and safety management planning
- Emergency response plan development
- Safety case preparation
- Compliance with regulations
- Non-standard operations analysis

PHAST software includes latest technical up gradation for carrying out modeling more realistically which includes Unified dispersion modeling, Droplet modeling, CO_2 modeling, and Enhanced models for Long Pipeline Calculations to handle difficult compositions and Time varying discharge enhancements to provide more realistic consequence and risk results.

PHAST Software is used to predict the physical behavior of hazardous incidents. The model uses below mentioned techniques to assess the consequences of identified scenarios:

- Modeling of discharge rates when holes develop in process equipment/pipe work.
- Modeling of the size & shape of the flammable gas clouds from releases in the atmosphere.
- Modeling of the flame and radiation field of the releases that are ignited and burn as pool fire, jet fire, Overpressure (Blast Force) and flash fire.
- Modeling of the explosion fields of releases which are ignited away from the point of release.

The consequence analysis results of worst case of the KSPL Aug of four stations (Koyali, Viramgam, Sidhpur and Kot) are given in the Table below-

Name of Station	**Jet Fire (m) 37.5 kW/m^2**	**Pool Fire (m) 37.5 kW/m^2**	**Overpressure (m) 0.2068 bar**	**Flash Fire (m) 5250 ppm**
Kot(Pipeline) leak	12	20	14	17
Kot (LBT tank) leak	9	8	Not Recorded	18
Sidhpur pipeline leak	13	6	11	19
Viramgam pipeline leak	18	16	37	19
Koyali pipeline leak	18	14	15	19

1.3 Risk Criteria

Individual risks are the key measures of risk acceptability for this type of study, where it is proposed that:

Risks to the public can be considered to be broadly acceptable (or negligible) if below 10^{-6} per year (one in 1 million years). Although risks of up to 10^{-4} per year (1 in 10,000 years) may be considered acceptable *if* shown to be As Low As Reasonably Practicable (ALARP), it is recommended that 10^{-5} per year (1 in 100,000 years) is adopted for this study as the maximum tolerable criterion.

Risks to workers can be considered to be broadly acceptable (or negligible) if below 10^{-5} per year and where risks of up to 10^{-3} per year (1 in 1000 years) may be considered acceptable if ALARP.

After assessment the risk it is found that risk to worker and public from the augmentation of Koyali Sanganer pipeline from stations Koyali, Viramgam, Sidhpur and Kot is below the ALARP region i.e. 10^{-6} per year (one in 1 million years) which is broadly acceptable or negligible.

The overall worst case scenario for Stations Koyali, Viramgam, Sidhpur and Kot are given in Figure below-

Figure 1:- Graph showing worst case scenario for KSPL Aug (Koyali)

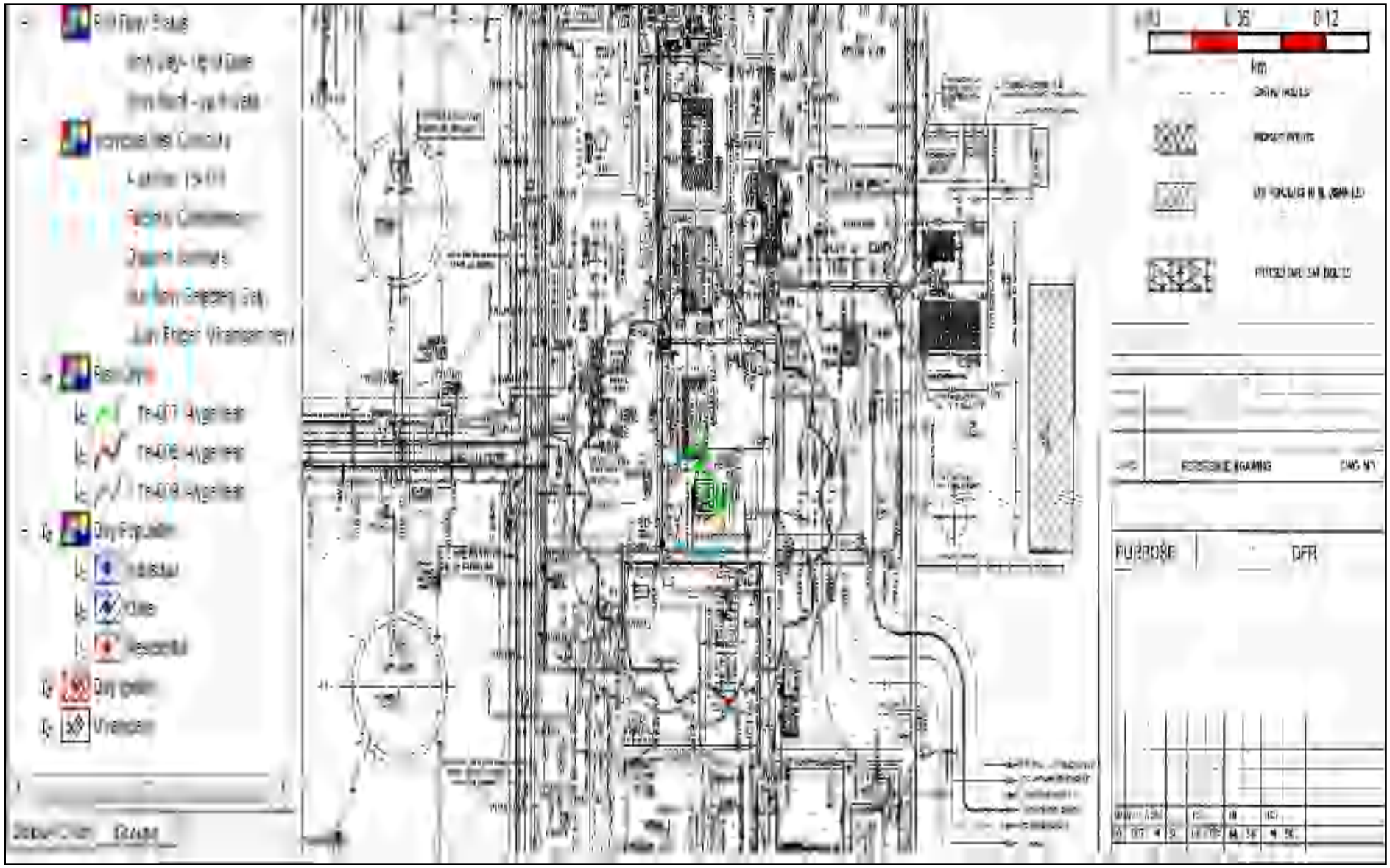

Figure 2:- Graph showing worst case scenario for KSPL Aug (Viramgam)

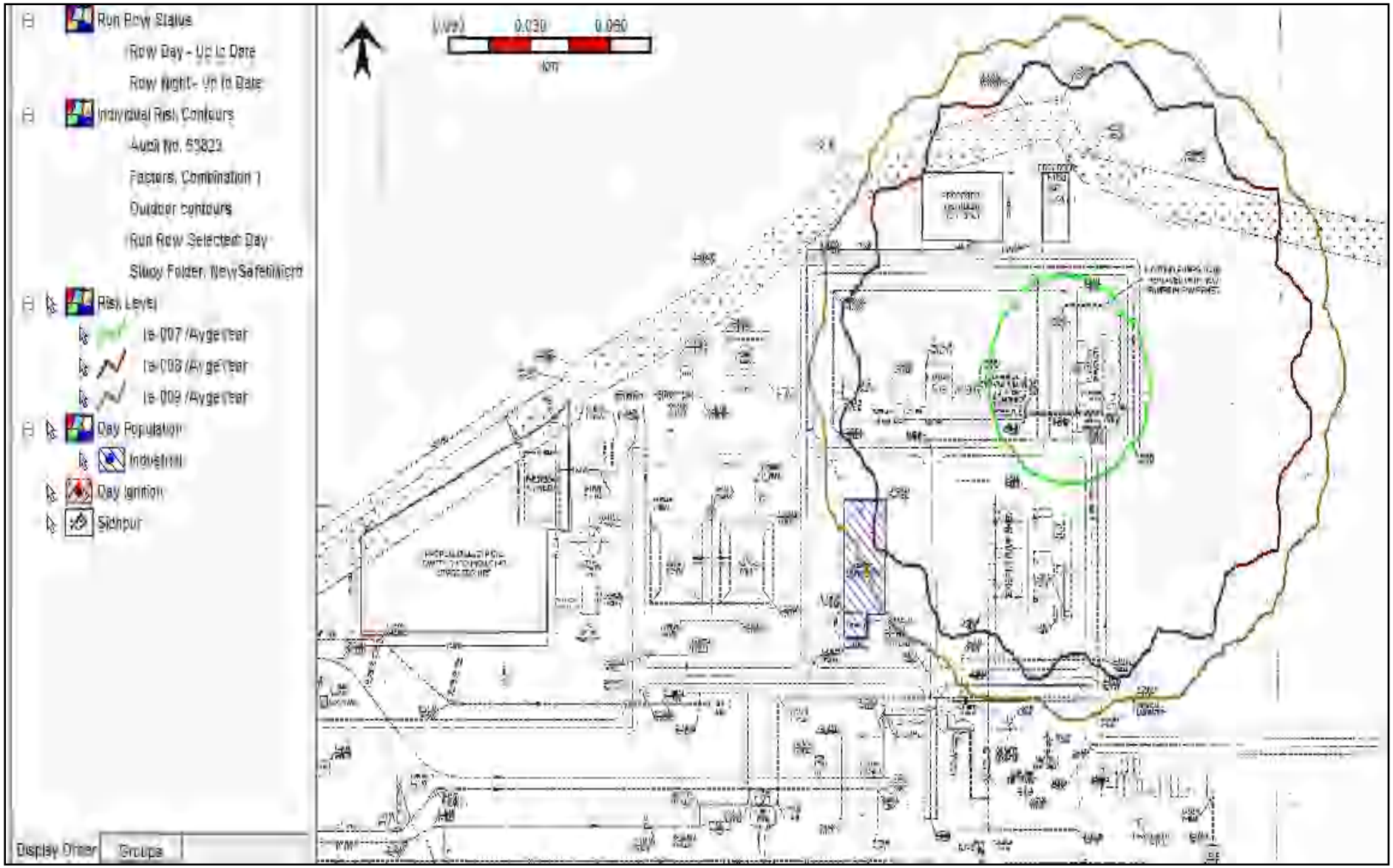

Figure 3:- Graph showing worst case scenario for KSPL Aug (Sidhpur)

Figure 4:- Graph showing worst case scenario for KSPL Aug (Kot)

The maximum LSIR (Location Specific Individual Risk) in the terminal/stations are listed in **Table** below-

Table 1: Maximum Location Specific Individual Risk at Stations/Terminal

S. No.	Unit	Maximum LSIR
1.	Koyali Station Control room	1 X 10^{-08} per year
2.	Viramgam Station Control room	1 X 10^{-09} per year
3.	Sidhpur Station Control room	1 X 10^{-08} per year
4.	Kot Station Control room	1 X 10^{-08} per year

1.3.1 Individual risk to worker (ISIR)

The Location specific individual risk (LSIR) is risk to a person who is standing at that point 365 days a year and 24 hours a day. The personnel in Koyali, Viramgam, Sidhpur and Kot stations are expected to work 8 hours shift as well as general shift. The actual risk to a person i.e. "Individual Specific Individual Risk (ISIR)" would be far less after accounting for the time fraction a person is expected to spend at a location.

$ISIR_{Area} = LSIR \times (8/24)_{(8\ hours\ shift)} \times$ (Time spent by and individual/8 hours)

The maximum ISIR in the units are listed in **Table** below-

Table 2:- Maximum Individual Specific Individual Risk (ISIR) at Stations/Terminal

S. No.	Unit	Maximum ISIR
1.	Koyali Station Control room	3.33 X 10^{-09} per year
2.	Viramgam Station Control room	3.33 X 10^{-10} per year
3.	Sidhpur Station Control room	3.33 X 10^{-09} per year
4.	Kot Station Control room	3.33 X 10^{-09} per year

ALARP summary & comparison of Individual risk with acceptability criteria.

The objective of this RA study is to assess the risk levels at KSPL stations (Koyali, Viramgam, Sidhpur and Kot Stations) with reference to the defined risk acceptability criteria and recommend measures to reduce the risk level to as low as reasonably practicable (ALARP).

The comparison of maximum individual risk with the risk acceptability criteria is shown in Figure below.

From the results shown above, the maximum individual risk to terminal/stations personnel estimated as 1 X 10^{-09} per year is lower part of ALARP region.

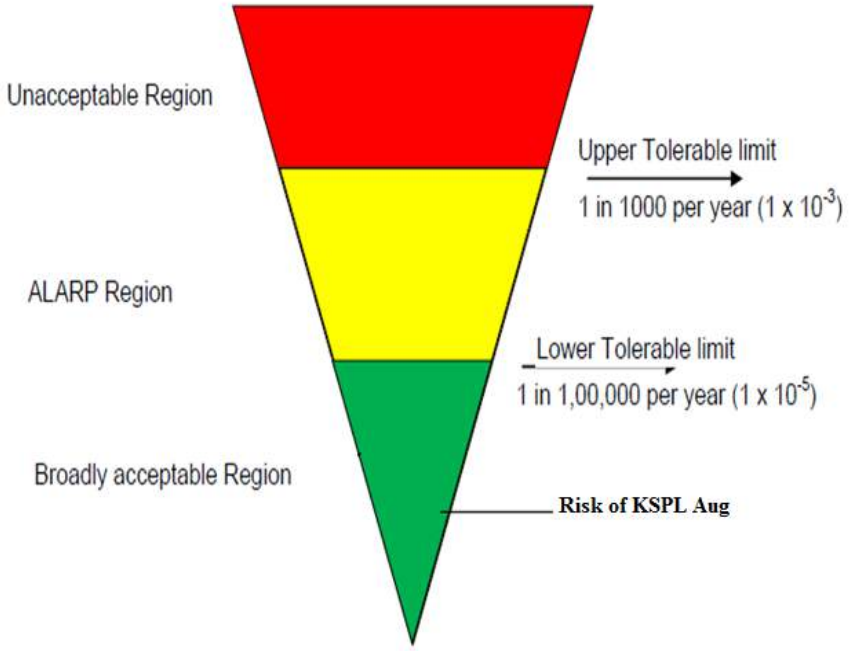

Figure 5:- Individual risk at KPSL Stations (Koyali, Viramgam, Sidhpur and Kot Stations)

Societal risk criteria are also proposed, although these should be used as guidance only.

A criterion of 10^{-4} per year is recommended for determining design accidental loads for on-site buildings, i.e. buildings should be designed against the fire and explosion loads that occur with a frequency of 1 in 10,000 years.

The result from the F-N curve show that the Societal risk due to KSPL aug i.e. from Koyali, Viramgam, Sidhpur and Kot Stations is below the ALARP Region which is broadly acceptable or negligible risk.

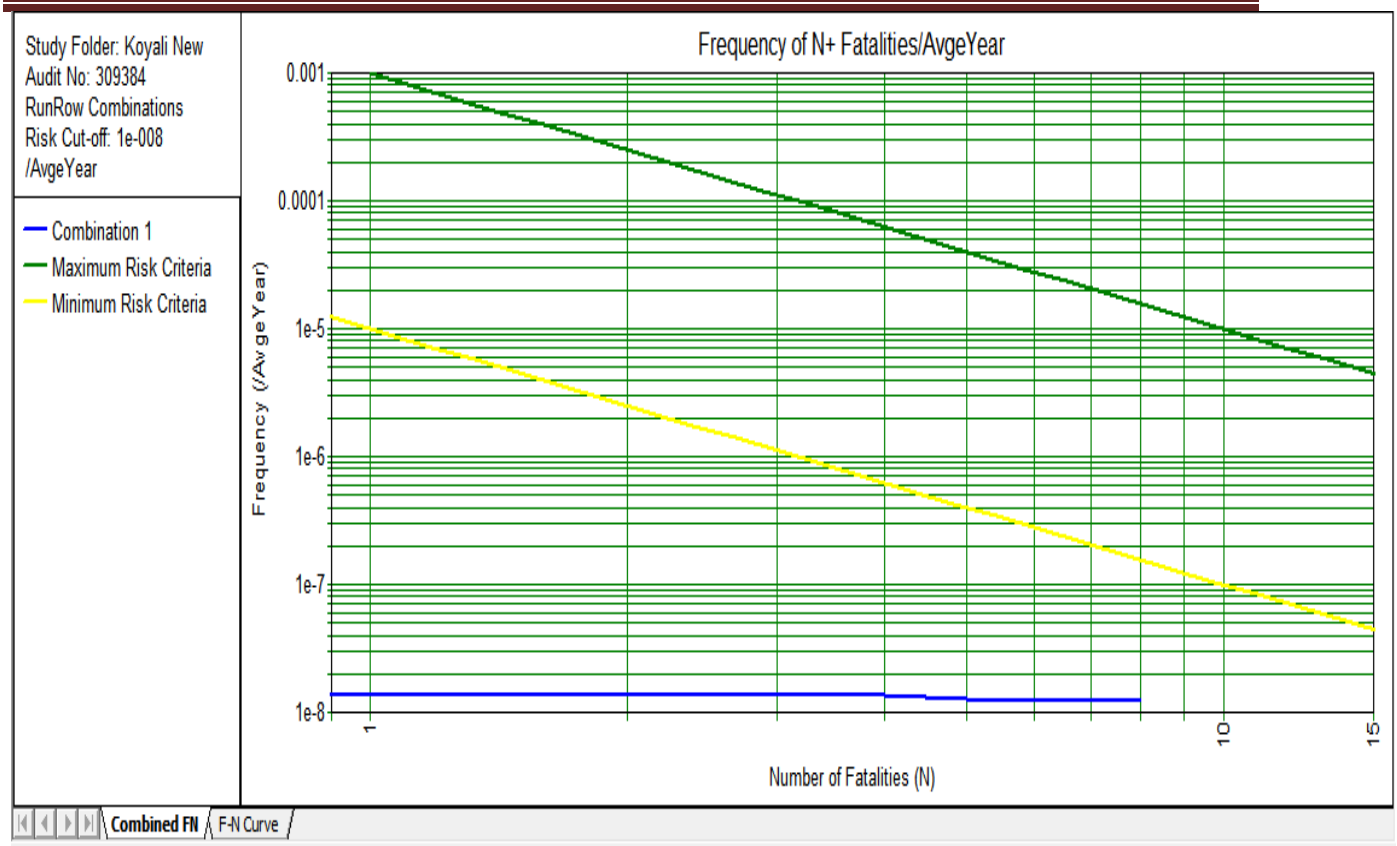

Figure 6:- F-N Curve for Group Risk of Koyali Station

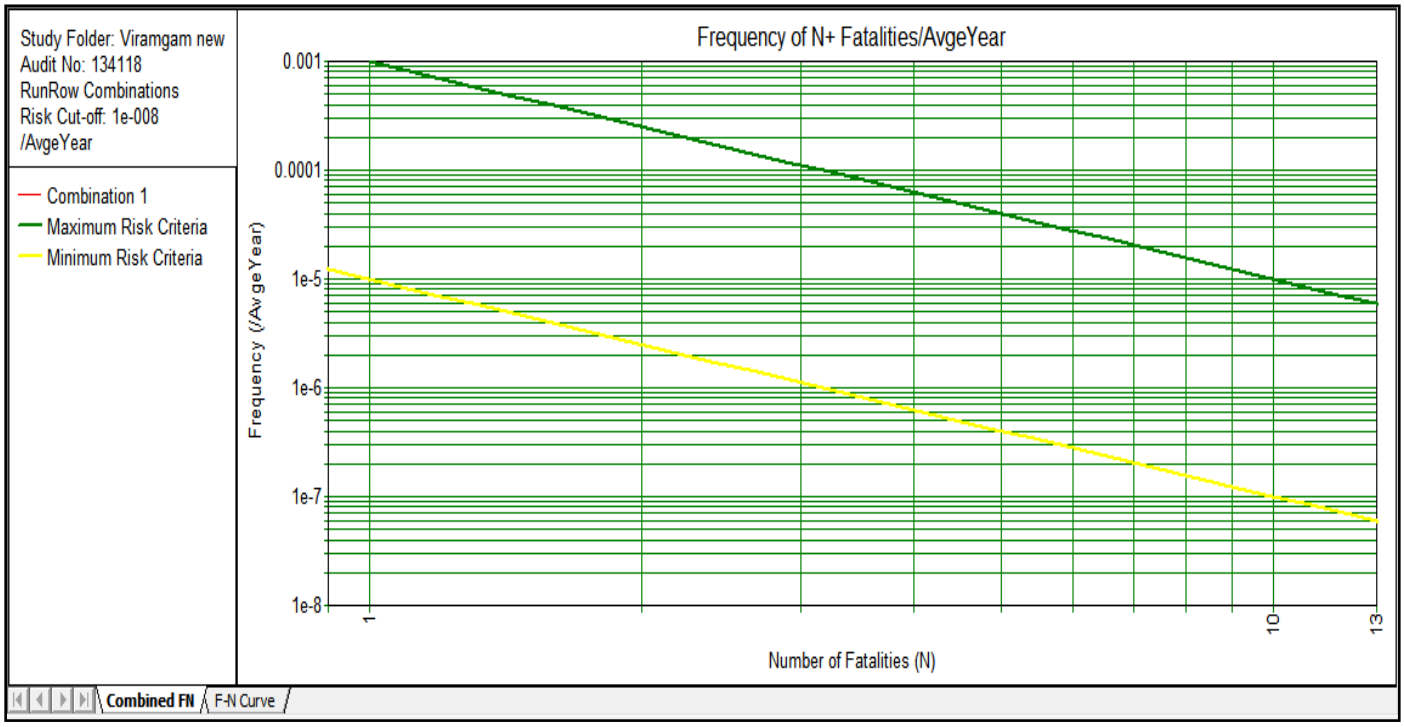

Figure 7:- F-N Curve for Group Risk of Viramgam station

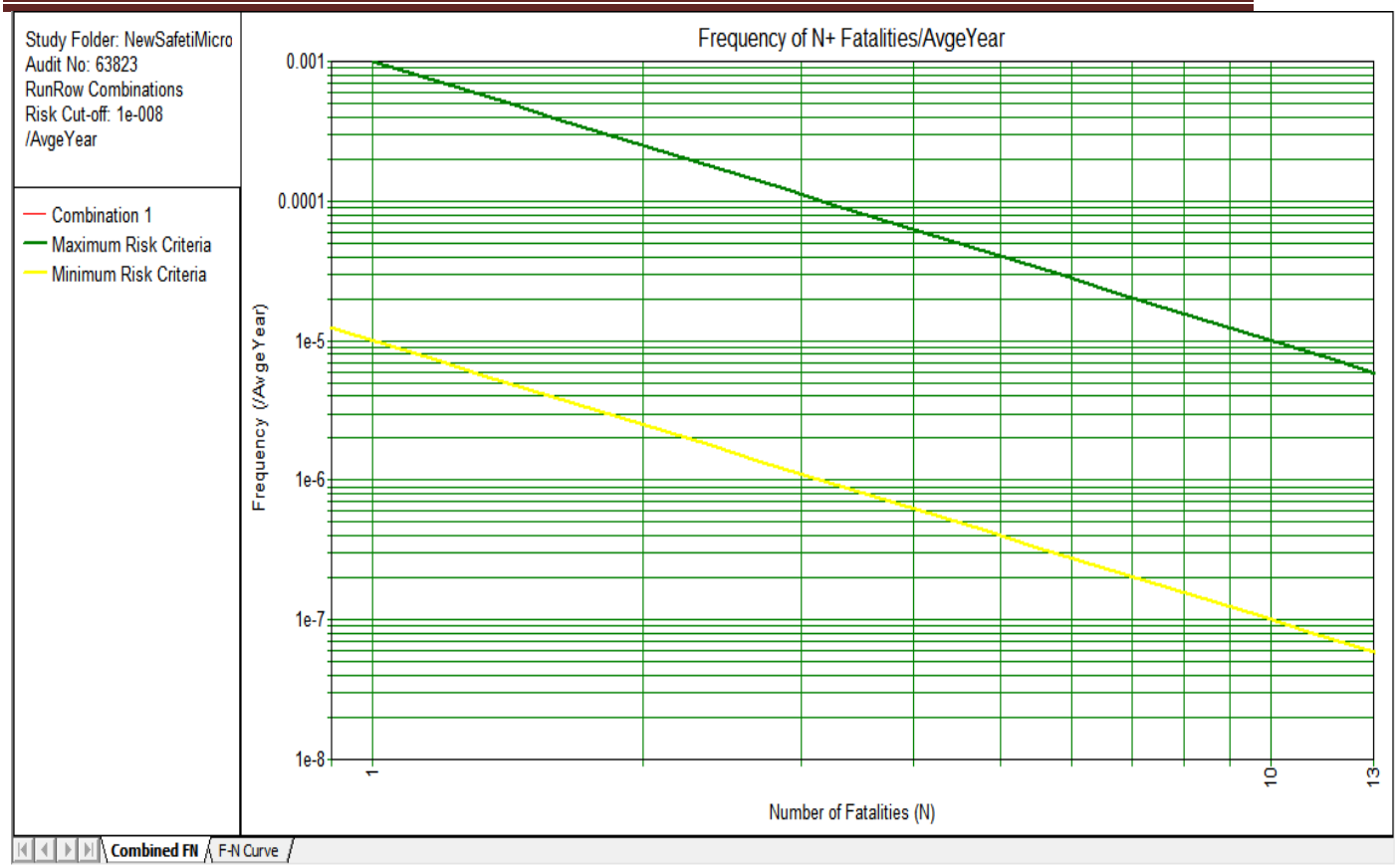

Figure 8:- F-N Curve for Group Risk of Sidhpur Station

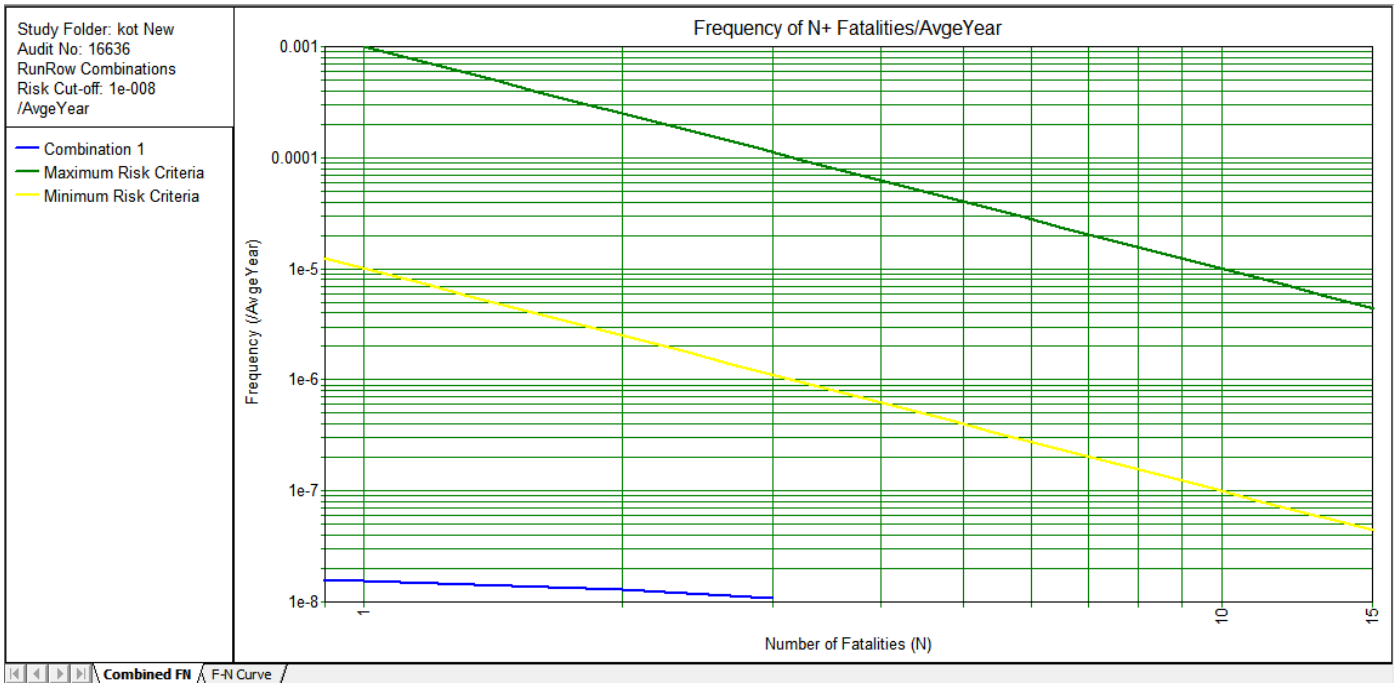

Figure 9:- F-N Curve for Group Risk of Kot Station

1.3.2 Top risk contributors (Group Risk)

The present major contributing scenarios to societal risk in Stations/terminal are broadly acceptable as it is lower part of ALARP region.

1.4 Conclusions and Recommendations

Although the results of this Risk analysis show that the risks to the public are broadly acceptable (or negligible), they will be sensitive to the specific design and/or modeling assumptions used.

The maximum risk to persons working in the Stations/terminal is 1 X 10^{-08} per year, 1 X 10^{-09} per year, 1 X 10^{-08} per year and 1 X 10^{-08} per year for Koyali, Viramgam, Sidhpur and Kot stations respectively which is below the acceptable level and is in the lower part of ALARP triangle.

It is observed that the ISO-risk contour of 1 X 10^{-08} per year, 1 X 10^{-09} per year, 1 X 10^{-08} per year and 1 X 10^{-08} per year for Koyali, Viramgam, Sidhpur and Kot stations respectively are within the Station/terminal. The ISO-Risk Contour of 1 X 10^{-09} per year for Koyali, Sidhpur and Kot station extended to the adjoining facilities which are having generally agriculture land.

The major conclusions and recommendations based on the risk analysis of the identified representative failure scenarios are summarized below:

- The pipeline, Stations/terminal are covered in the process safety management system of IOCL.
- It is necessary to provide fire and gas detection system in the stations/terminal. Operators are well trained about the fire and gas detection system.
- It is recommended to have necessary provision for emergency stop of critical equipments from control room in the event of major leak/flash fire.
- The vehicles entering the Stations/terminal should be fitted with spark arrestors and should not be allowed to enter battery area.
- Routine checks to be done to ensure and prevent the presence of ignition sources in the immediate vicinity of the Stations/terminal (near boundaries).
- Clearly defined escape routes shall be developed for each individual plots and section of the Stations/terminal taking into account the impairment due to escape of hazardous releases and sign boards be erected in places to guide personnel in case of an emergency.
- Well defined emergency safe locations within station shall be identified for assembling of personnel in one place in case of an emergency.

- Windsocks shall be considered in the plant at prominent place to assist personnel to see the wind direction. This will assist people to escape in upwind or cross wind direction from flammable releases.

- In order to further reduce the probability of failure of catastrophic rupture of pipeline and equipments, critical equipments shall be identified and inspection methodologies to be finalized for continuous monitoring during operation and shutdown maintenance.

- The active protection devices like fire water sprinklers and other protective devices shall be tested at regular intervals.

- There should be Standard Operating procedures (SOP) for clarity of actions to be taken in case of emergencies like fire/leak.

1.5 General Recommendations

1. Damage distances for the worst case could affect nearby facilities within the stations/terminal and some minimal direct effect on nearby hutments is possible. Due care should be taken if the road is close by and hence close co-ordination with administration is important. As such, the traffic is moderate and no cause of major concern.

2. Ensure that combustible flammable material is not placed near the Critical instruments of the Station/terminal. These could include oil filled cloth, wooden supports, oil buckets etc. these must be put away and the areas kept permanently clean and free from any combustibles. Secondary fires probability would be greatly reduced as a result of these simple but effective measures.

3. Remotely Operated Shutoff Valves (ROSOV) and Hydrocarbon detectors should be provided to the pump house of the Station/Terminal as per guidelines of OISD.

4. Proper lighting arrangements and CCTV should be provided at terminal/stations.

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CHAPTER-2: INTRODUCTION

2.1 Introduction

The entire demand for petroleum products of North Gujarat and Rajasthan is currently met from Koyali refinery through Koyali-Sanganer Pipeline (KSPL). In the absence of any alternative means of supply, product placement at these locations gets severely affected in event of shutdown of Koyali refinery, thereby necessitating supply from other sources through un-economical modes. To address this problem new pumping units at Kandla have been approved, which involves transportation of products received coastally from Kandla till Viramgam only, while further transportation and delivery to Tap-off-Points (ToP) at Sidhpur, Salawas, Chittaurgarh and Jaipur will be done through KSPL after its augmentation.

Also, considering the expansion of PNC and additional availability of Naphtha from other units of Panipat refinery, the annual additional requirement of Naphtha is around 800 TMT. This requirement of naphtha is to be met through tank wagons through rail movement from Koyali to Panipat. Considering the volume to be transported and the inherent advantage of pipeline over other modes viz. safety, reliability, less energy consumption, environment-friendliness etc, it is prudent to transport Naphtha through Koyali-Sanganer Pipeline (KSPL) upto Sanganer and from Sanaganer, IOCL proposes to lay a new 340 kms pipeline (Jaipur-Panipat Pipeline). The transportation of Naphtha also necessitates augmentation of KSPL.

This report contains the Risk Analysis study for the Augmentation of Koyali-Sanganer pipeline project originated from Koyali refinery. The study is broadly divided into the following:

- Identification of hazards
- Effects Estimation
- Consequence Analysis
- Risk Estimation
- Risk Reduction.

2.2 Scope of Study

Mantec Consultants Pvt. Ltd, D-36, Sector-6, NOIDA (U.P.) is appointed for carrying out the Risk Analysis & HAZOP/HAZID study. The objective of the Risk Analysis & HAZOP/HAZID study is to identify vulnerable zones, major risk contributing events, understand the nature of risk posed to nearby areas and form a basis for the Emergency Response Disaster Management Plan (ERDMP). In addition, the Risk Analysis & HAZOP/HAZID study is also necessary to ensure compliance to statutory rules and regulations. Risk assessment methodology is given in the following Figure.

Risk Analysis broadly comprises of the following steps:

- Project Description
- Identification of Hazards and Selection of Scenarios
- Effects and Consequence Calculations
- Risk Summation (Risk calculation)
- Risk assessment (using an acceptability criteria)
- Risk Mitigation Measures

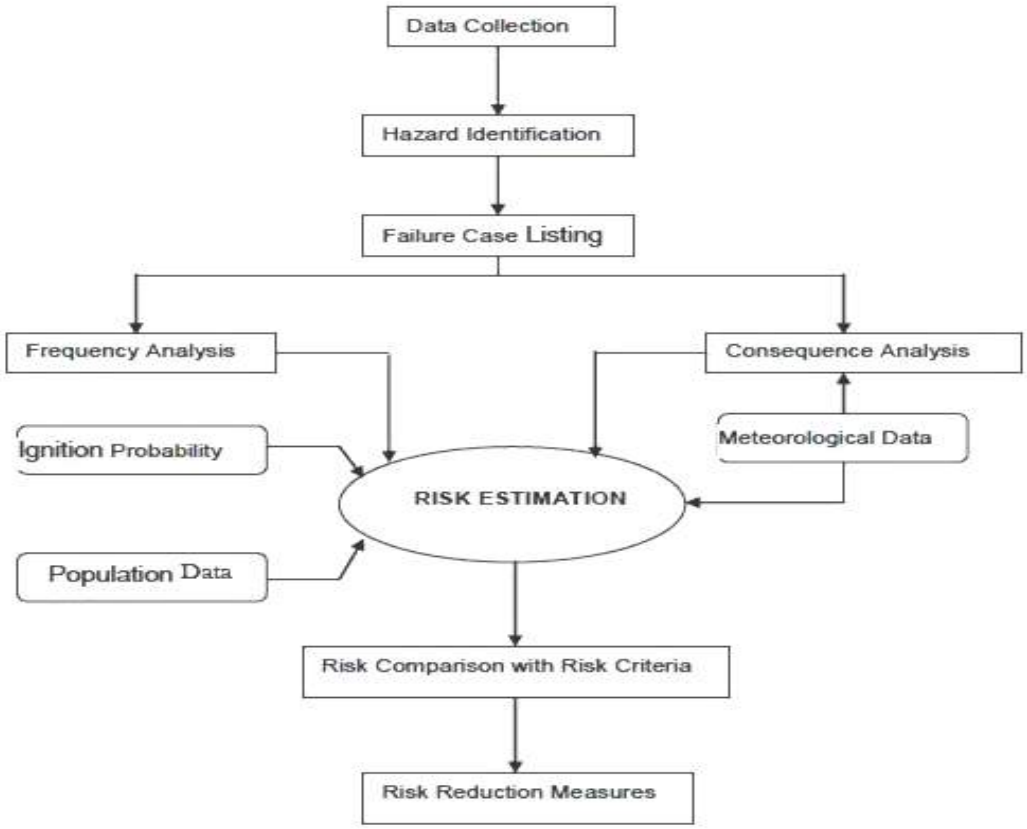


Figure 10:- Risk Assessment Methodology

2.3 Execution Methodology

The methodology adopted for executing the assignment is briefly given below:

2.3.1 Kick off meeting with Mantec

This was done to set the basis of studies, objectives and related matters and also to identify in detail the facilities to be covered in the RA.

2.3.2 Study of IOCL operations

This was carried out for carrying out the risk assessment study for Augmentation of Koyali-Sanganer Pipeline project.

2.3.3 Study of IOCL operating parameters

This involved collection of pertinent project information on the operation and process details such as P&ID's, process flow diagram and Plant Layout. Critical instruments, their temperature and pressure and other details. The data so collected would ensure a more realistic picture for the risks subsequently identified and estimated.

2.3.4 Identification of hazards

This includes estimation of possible hazards through a systematic approach. It typically covers identification and grouping of a widely ranging possible failure cases and scenarios. The scenario list was generated through generic methods for estimating potential failures (based on historical records based on worldwide and domestic accident data bases) and also based on IOCL's experience in operating the facilities.

2.3.5 Consequence Effects Estimation

This covers assessing the damage potential in terms of heat radiation.

CHAPTER-3: PROJECT DESCRIPTION

3.1 Pipeline Description

Salient features of the Augmentation of Koyali-Sanganer pipeline are described below:

- Replacement of 1 existing motor driven MLPU (Main Line Pumping Unit) at Koyali with new MLPU of adequate capacity.
- Replacement of two existing mainline pumps at Koyali with new pumps of adequate capacity.
- Installation of 3 (2+1) motor driven MLPU's of adequate capacity at Viramgam for Pumping in Viramgam-Sidhpur section.
- Replacement of all existing engine/motor driven MLPU's at Sidhpur and Kot with new MLPU's of adequate capacity.
- 1 LBT of 10,000 KL nominal capacity at Kot.

All the existing facilities of pumping station like fire fighting, electrical system, Pump house, Pipeline etc. would comply with national, internal standards and M.B. Lal committee recommendations.

3.2 Type of Project

The augmentation of KSPL is to enhance the capacity of pipeline upto 6 MMTPA of petroleum products.

The need of the augmentation of Koyali-Sanganer pipeline (KSPL) is entirely on the additional product requirement of ToPs en-route existing KSPL. The additional products will either be coming from Koyali refinery or from Kandla port upto Viramgam where from they will be transported through existing KSPL. Also there is requirement of transportation of 800 TMT Naphtha from Koyali Refinery to Naphtha Cracker in Panipat which will also be met through augmentation of KSPL. Naphtha will be transported from Koyali to Sanganer in existing KSPL and further to Panipat through new Jaipur-Panipat Naphtha Pipeline.

3.2.1 Importance of the Project

The main purpose of the project is as follows-

- Transportation of petroleum products coming from Kandla to Viramgam, existing ToP's of KSPL.
- Increased projection of petroleum products at existing ToP's of KSPL.

3.3 Location

The augmentation work will be carried out at Koyali, Viramgam, Sidhpur and Kot stations.

The nearest city from the stations/terminal is given in **Table** below-

Table 3:- Nearest City along with Distance

S. No.	Station/Terminal	Nearest city name and distance
1.	Koyali	Vadodara: Approx 7 km SW
2.	Viramgam	• Viramgam Approx. 3 km, • Ahmedabad Approx. 60 km, W
3.	Sidhpur	Sidhpur, Approx 1.25 SW
4.	Kot	Bali, Approx 5.6 km E

Location Map of the project is given in **Figure** below-

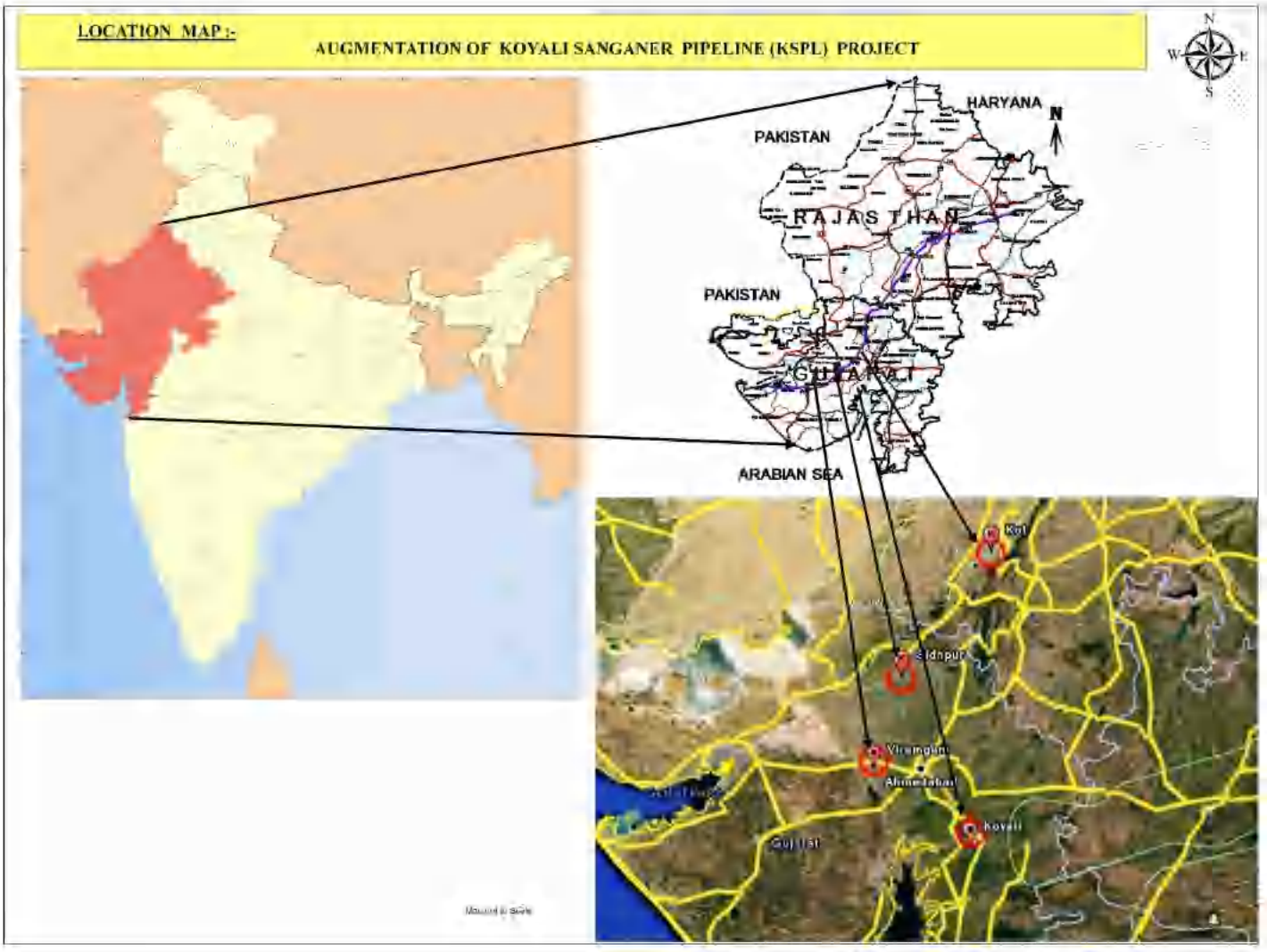


Figure 11:- Location of Augmentation of Koyali-Sanganer Pipeline Project

The Plant layouts of Koyali station, Viramgam Station, Sidhpur station and Kot station are attached as **Annexure-E.**

3.4 Existing Facilities at the Project Site

The existing facilities at the project site are given in Table below-

Table 4: Existing Facilities at the Project Site

Koyali Station details:

Station Area	Within refinery Campus
Pipeline	1. 08" dia Koyali- Ahmedabad Pipeline 2. 18" dia Koyali- Sanganer pipeline 3. 14" dia Koyali- Dahej Pipeline 4. 16'' dia Koyali- Ratlam Pipeline
Water consumption	3 KL per day
DG set	Supply from Refinery.
FF facilities	Extinguishers, FF water network,
Stations facilities	Boosters (2+1), MLPU motor driven (2+1), strainers, sump tank of 20 kls, control valve. Corrosion Inhibitor pumping motor, Flow meter, Scrapper launching barrel, HT/LT panel, Control system.

Viramgam station Details:-

Station Area	160 acre(s)
Pipelines	1. Salaya Mathura Crude pipeline 2. Koyali-Viramgam Section of KSPL
Water consumption	150 L per day.(engine cooling)
DG set	1 x 1250 KVA 1 x 1000 KVA
FF facilities	Fire fighting motor and engine driven Pumps, Water ponds, FF extinguishers, FF water network, and Hydrocarbon detectors.
Stations facilities	Engine driven pumping units motors, strainers, Flow meters, Control valves, Motor operated valves, PLC, SCADA, LDS, Electrical Control panels, scrapper launching and receiving barrel, telecom System, UPS, Crude oil Tanks.

Sidhpur station Details:-

Land	15.76 acre(s)
Pipeline	1. Mundra-Panipat Pipeline. 2. Sidhpur-Sanganer Pipeline.
Water consumption	108 KL per day. (mostly in engine cooling system)
DG set	1 x 400 KVA
FF facilities	FF pumps, water Pond, Hydrocarbon detection systems. FF motor, engines, above ground Fire fighting water network, Fire extinguishing equipment including CO2 suppression system and foam sprinkler system,

Stations facilities	Pumping units, Boosters, strainers, Flow meters, Control valves, Motor operated valves, PLC, SCADA, LDS, Electrical Control panels, scrapper receiving barrels, Transformer, Emergency Generator, telecom System, UPS, etc.

Kot station Details:-

Station Area	19.46 acre(s)
Pipelines	1. Mundra Panipat Crude Pipeline (MPPL) 2. Sidhpur-Sanganer Pipeline 3. Salaya-Mathura Pipeline
Water consumption	2.5 KL per day.
DG Set	1X500 KVA 1x 400 KVA
FF facilities	FF pumps, above ground Fire fighting water network, Fire extinguishing equipment including CO2 suppression system and foam sprinkler system. Fire water tanks Hydrocarbon detection systems.
Stations facilities	Pumping units(engine driven/motor driven), Boosters, strainers, Flow meters, Control valves, Motor operated valves, PLC, SCADA, LDS, Electrical Control panels, scrapper receiving barrels, Unloading pumps, Corrosion inhibitor pumping units, Compressors, Sump tank with motor, telecom System, UPS etc.

3.5 Site Condition

The land use at stations is flat and land use of pipeline is varying from flat to simple terrain. The Pumping stations are in Gujarat and Rajasthan state. Koyali refinery, Viramgam station, Sidhpur station all are located in the flat plain of the state of Gujarat and Kot Station located in the flat plain of Rajasthan state. The average elevation of the sites Koyali, Viramgam, Sidhpur and Kot is around 45 m, 26 m, 130 m and 315 m respectively.

3.5.1 Population

The population details of the terminal/stations are given in **Table** below-

Table 5: Population Details at station/terminal

S. No.	Location of Terminal/Pumping Station	Population Detail
1.	Koyali	Day time-45(Employees) + 25 Maintenance workers & Vehicle drivers, Shift duty (Day & Night)- Total 18 Nos. i.e. @ 6 No. in each shift.
2.	Viramgam	Day time-150(Employees) + 50 Maintenance workers & Vehicle drivers, Shift duty (Day & Night)- Total 16 Nos. i.e. @ 6 No. in each shift(Approx).
3.	Sidhpur	Total no. of employees-30 and 1 person for security cabin
4.	Kot	45 no. of employees and in shift duty(Day/Night) at a time 5 persons available in both control rooms(SMPL+MPPL/KSPL)

3.5.2 Ignition Source

The ignition sources within and outside the terminal/station is a key factor in performing RA Study. The ignition sources, combined with their ignition probability, wind directional probability and presence of flammable hydrocarbon is a key factor in determining the delayed ignition probability of the cloud which further results in flash fire and overpressure scenarios.

The various ignition sources considered in the study includes canteen, traffic movement on the nearby road of the terminal/station.

3.5.3 Meteorological Condition

Details of Metrological Data are attached as **Annexure-D.**

The consequences of released flammable material are largely dependent on the prevailing weather conditions. For the assessment of major scenarios involving release of flammable materials, the most important meteorological parameters are those that affect the atmospheric dispersion of the releasing material. The critical variables are wind direction, wind speed, atmospheric stability and temperature. Rainfall does not have any direct bearing on the results of the risk analysis; however, it can have beneficial effects by absorption/washout of released materials. Actual behavior of any release would largely depend on prevailing weather condition at the time of release.

3.6 Pasquill Stability

One of the most important characteristics of atmosphere is its stability. Stability of atmosphere is its tendency to resist vertical motion or to suppress existing turbulence. This tendency directly influences the ability of atmosphere to disperse pollutants released from the facilities. In most dispersion scenarios, the relevant atmospheric layer is that nearest to the ground, varying in thickness from a few meters to a few thousand meters. Turbulence induced by buoyancy forces in the atmosphere is closely related to the vertical temperature gradient.

Temperature normally decreases with increasing height in the atmosphere. The rate at which the temperature of air decreases with height is called Environmental Lapse Rate (ELR). It varies from time to time and place to place. The atmosphere is considered to be stable, neutral or unstable according to ELR is less than, equal to or greater than Dry Adiabatic Lapse Rate (DALR), which is a constant value of 0.98°C/100 meters.

Pasquill stability parameter, based on Pasquill – Gifford categorization, is a meteorological parameter, which describes the stability of atmosphere, i.e., the degree of convective turbulence. Pasquill has defined six stability classes ranging from `A' (extremely unstable) to `F' (stable). Wind speeds, intensity of solar radiation (daytime insulation) and night time sky cover have been identified as prime factors defining these stability categories.
The Pasquill stability classes are shown in **Table** below-

Table 6: Pasquill stability classes

Surface Wind	**Day time solar radiation.**			**Night time cloud cover**		
Speed(m/s)	**Strong**	**Slight**	**Slight**	**Thin< 40%**	**Medium**	**Overcast >80%**
< 2	A	A-B	B	-	-	D
2-3	A-B	B	C	E	F	D
3-5	B	B-C	C	D	E	D
5-6	C	C-D	D	D	D	D
>6	C	D	D	D	D	D

When the atmosphere is unstable and wind speed is moderate or high or gusty, rapid dispersion of pollutants will occur. Under these conditions, pollutant concentration in air will be moderate or low and the material will be dispersed rapidly. When the atmosphere is stable and wind speed is low, dispersion of material will be limited and pollutant concentration in air will be high.

Stability category for this study is identified based on the cloud amount, day time solar radiation and wind speed.

Table 7: Weather parameters for consequence analysis

S. No.	Wind Speed(m/s)	Pasquill Stability
1.	1.5	F
2.	5	D

The consequence modeling has been done on the basis of above mentioned weather parameters for all stations/terminal.

3.6.1 Fire Fighting Facility

All facilities at the station/terminal are as per OISD-116/117 standards.

3.6.2 Other Facility

CCTV should be provided at the relevant location.

CHAPTER-4: IDENTIFICATION OF HAZARD AND SELECTION OF SCENARIOS

4.1 Hazard identification

A classical definition of hazard states that hazard is in fact the characteristic of system/plant/process that presents potential for an accident. Hence all the components of a system/plant/process need to be thoroughly examined in order to assess their potential for initiating or propagating an unplanned event/sequence of events, which can be termed as an accident.

In Risk Analysis terminology a hazard is something with the potential to cause harm. Hence the Hazard Identification step is an exercise that seeks to identify what can go wrong at the major hazard installation or process in such a way that people may be harmed. The output of this step is a list of events that need to be passed on to later steps for further analysis.

The potential hazards posed by the facility were identified based on the past accidents, lessons learnt and a checklist. This list includes the following elements. Catastrophic rupture of pressure vessel. “Guillotine-Breakage” of pipe-work Small hole, cracks or instrument tapping failure in piping and vessels. Flange leaks. Leaks from pump glands and similar seals.

Modes of Failure

There are various potential sources of large leakage, which may release hazardous chemicals and hydrocarbon materials into the atmosphere. These could be in form of gasket failure in flange joints, bleeder valve left open inadvertently, an instrument tubing giving way, pump seal failure, guillotine failure of equipment/pipeline or any other source of leakage. Operating experience can identify lots of these sources and their modes of failure. A list of general equipment and pipeline failure mechanisms is as follows:

Material/Construction Defects

- Incorrect selection or supply of materials of construction
- Incorrect use of design codes
- Weld failures
- Failure of inadequate pipeline supports

Pre-Operational Failures

- Failure induced during delivery at site
- Failure induced during installation
- Pressure and temperature effects

- Overpressure
- Temperature expansion/contraction (improper stress analysis and support design)
- Low temperature brittle fracture (if metallurgy is incorrect)
- Fatigue loading (cycling and mechanical vibration)

Corrosion Failures

- Internal corrosion (e.g. ingress of moisture)
- External corrosion
- Cladding/insulation failure (e.g. ingress of moisture)
- Cathodic protection failure

Failures due to Operational Errors

- Human error
- Failure to inspect regularly and identify any defects

External Impact Induced Failures

- Dropped objects
- Impact from transport such as construction traffic
- Vandalism
- Subsidence
- Strong winds

Failure due to Fire

- External fire impinging on pipeline or equipment
- Rapid vaporization of cold liquid in contact with hot surfaces

4.2 Hazards associated with the Station/Terminal

The pipeline and their associated station/terminal handle hazardous petroleum products which have a potential to cause fire and explosion hazards. This chapter describes in brief the hazards associated with this material.

4.3 Hazards Associated with Flammable Hydrocarbons

The list of hazardous materials is as follows-

4.3.1 Motor Spirit (MS)

The Motor Spirit (MS) is also known as the Petrol or Gasoline. The properties (chemical and physical) of MS and Fire and Explosion Data is indicated in **Table** (MSDS Table) given below-

IDENTITY OF MATERIAL

Table 8: Material Safety Data Sheet (MSDS) of Motor Spirit (MS)

PRODUCT NAME	PETROL, MOTOR SPIRIT
TRADE NAME	GASOLINE
FORMULA	COMPLEX MIXTURE OF HYDROCARBONS
UN No.	1203
CAS No.	86290-81-5
HAZCHEM CODE	3Y*E
LABEL/CLASS	RED & WHITE FLAMMABLE LIQUID/3.2 GROUP II

Table 9: Physical and Chemical Properties of Motor Spirit (MS)

PHYSICAL STATE	LIQUID	**BOILING POINT/RANGE (^oC)**	30 to 215
APPEARANCE	COLOURLESS	**MELTING/FREEZING POINT/RANGE (^oC)**	90 to -75
SOLUBILTY in WATER	INSOLUBLE	**VAPOR DENSITY (AIR=1)**	3 to 4
CALORIFIC VALUE (Kcal/Kg)	4.5E+07	**SPECIFIC GRAVITY, 20^oC**	0.72 to 0.77
VAPOR PRESSURE at 20^oC, mm Hg	300 to 600	**HEAT OF VAPORIZATION, Kcal/Kg**	2.93E+05
EVAPORATION RATE at 30^oC	10 APPROX.	**SPECIFIC HEAT LIQUID J/Kg**	2.2E+03

Table 10: Fire and Explosive Data of Motor Spirit (MS)

EXPLOSIVITY	MODERATE	**AUTO IGNITION TEMP., ^oC**	257	**FLASH POINT, ^oC**	<23
FLAMMABILITY	DANGEROUS	**EXPLOSIVE LIMITS, %**	1.3-7.6	**BURNING RATE**	4 mm/min

4.3.2 High Speed Diesel (HSD)

The High Speed Diesel is commonly known as the Diesel Oil. The properties (chemical and physical) of HSD and Fire and Explosion Data is indicated in **Table** (MSDS Table) given below-

IDENTITY OF MATERIAL

Table 11: Material Safety Data Sheet (MSDS) of High Speed Diesel (HSD)

PRODUCT NAME	DIESEL OIL,GAS OIL
TRADE NAME	HSD
FORMULA	COMPLEX MIXTURE of HYDROCARBONS
UN No.	1202
HAZCHEM CODE	3Y*
LABEL/CLASS	RED FLAMMABLE LIQUID

Table 12: Physical and Chemical Properties of High Speed Diesel (HSD)

PHYSICAL STATE	LIQUID	**BOILING POINT/RANGE (^oC)**	150-400
APPEARANCE	LIQUID BROWN	**VAPOR DENSITY (AIR=1)**	18 to 46
SOLUBILTY in WATER	INSOLUBLE (30 ppm)		
CALORIFIC VALUE (Kcal/Kg)	4.34E+07	**SPECIFIC GRAVITY, 20^oC**	0.82 to 0.86
VAPOR PRESSURE at 38^oC, mm Hg	<1	**HEAT OF VAPORIZATION, Kcal/Kg**	2.71E+05
DYNAMIC VISCOSITY (PA.SC 30 ^oC)	0.81 to 0.91	**SPECIFIC HEAT LIQUID J/Kg**	2.343E+03

Table 13: Fire and Explosive Data of High Speed Diesel (HSD)

EXPLOSIVITY	MODERATE	**AUTO IGNITION TEMP., ^oC**	256.6	**FLASH POINT, ^oC**	32 to 96
FLAMMABILITY	MODERATE	**EXPLOSIVE LIMITS, %**	0.7-5	**BURNING RATE**	4 mm/min

4.3.3 Superior Kerosene Oil (SKO)

The Superior Kerosene Oil is also known as the Stove Oil. The properties (chemical and physical) of SKO and Fire and Explosion Data is indicated in **Table** (MSDS Table) given below-

IDENTITY OF MATERIAL

Table 14: Material Safety Data Sheet (MSDS) of Superior Kerosene Oil (SKO)

PRODUCT NAME	KEROSENE, STOVE OIL, ILLUMINATING OIL
TRADE NAME	SKO
FORMULA	COMPLEX MIXTURE OF HYDROCARBONS
UN No.	1223
HAZCHEM CODE	3Y
LABEL/CLASS	RED FLAMMABLE LIQUID/3.3 GROUP II

Table 15: Physical and Chemical Properties of Superior Kerosene Oil (SKO)

PHYSICAL STATE	LIQUID	**BOILING POINT/RANGE (^oC)**	145-300
APPEARANCE	COLOURLESS	**VAPOR DENSITY (AIR=1)**	4.1
SOLUBILTY in WATER	0.0002 to 0.0004		
CALORIFIC VALUE (Kcal/Kg)	4.35E+07	**SPECIFIC GRAVITY, 20^oC**	0.80 to 0.85
VAPOR PRESSURE at 20^oC, mm Hg	5	**HEAT of VAPORIZATION, Kcal/Kg**	2.72E+05
MELTING/FREEZING POINT (^oC)	43 to -49	**SPECIFIC HEAT LIQUID J/Kg**	2.09E+03

Table 16: Fire and Explosive Data of Superior Kerosene Oil (SKO)

EXPLOSIVITY	MODERATE	**FLAMMABILITY**	256.6	**FLASH POINT, ^oC**	Min. 35

4.3.4 Naphtha

The properties (chemical and physical) of Naphtha and Fire and Explosion Data is indicated in **Table** (MSDS Table) given below-

Table 17: Material Safety Data Sheet (MSDS) of Naphtha

Material Identity	Naphtha
Other Name(s)	Naphtha, Petroleum Naphtha, Petroleum Solvent, Benzene, Mineral, Light Ligorin
Chemical Description	This material is a C5 to C17 hydrocarbon liquid which contains approximately 0 to 1.5 wt% sulfur compounds
Flammability	Highly flammable (Class II flammable liquid)

Table 18: Physical and Chemical Properties

Boiling Point	35°C to 205°C
Vapor Pressure	0 to 67 mmHg
Specific Gravity (@ 20^{O}C)	0.69 to 0.78
Solubility in Water	Insoluble
Appearance	Colourless liquid
Odor	Petroleum hydrocarbon odor
Calorific Value (Kcal/Kg)	4.5E+07
Vapor Density (AIR=1)	2.5 to 4.78

4.4 Selected Failure Cases

A list of failure cases was prepared based on process knowledge, engineering judgment, experience, past incidents associated with such facilities and considering the general mechanisms for loss of containment. The cases have been identified for the consequence analysis is based on the following.

- **Cases with high chance of occurrence but having low consequence:**

Example of such failure cases includes two-bolt gasket leak for flanges, seal failure for pumps, sample connection failure, instrument tapping failure, drains, vents, etc. The consequence results will provide enough data for planning routine safety exercises. This will emphasize the area where operator's vigilance is essential.

- **Cases with low chance of occurrence but having high consequence (The example includes catastrophic failure of lines, process pressure vessels, etc.)**

This approach ensures at least one representative case of all possible types of accidental failure events, is considered for the consequence analysis. Moreover, the list below includes at least one accidental case comprising of release of different sorts of highly hazardous materials handled in the Station/Terminal. Although the list does not give complete failure incidents considering all equipments, units, but the consequence of a similar incident considered in the list below could be used to foresee the consequence of that particular accident.

Table 19: Selected failure case for Pipeline

Equipment	Scenario	Flow rate (Kl/hr)	Pressure MOAP(mcl)	Temp (^{0}C)	Failure Frequency (per year)
Pipeline and pumping facilities at Koyali	Leakage from the Pipeline at Koyali	250 kl/hr	1301	Equal to ambient	$1.5 X 10^{-05}$
Pipeline and pumping facilities at Viramgam	Leakage from the Pipeline at Viramgam	250 kl/hr	860	Equal to ambient	$1.5 X 10^{-05}$
Pipeline and pumping facilities at Sidhpur	Leakage from the Pipeline at Sidhpur	250 kl/hr	1075	Equal to ambient	$1.5 X 10^{-05}$
Pipeline and pumping facilities at Kot	Leakage from the Pipeline at Kot	250 kl/hr	10..75	Equal to ambient	$1.5 X 10^{-05}$
Line balancing Tank at Kot	Leakage from the LBT at Kot	N.A.	Atmospheric storage tank	Equal to ambient	$2.8 X 10^{-03}$

4.5 Hazard identification as per NFPA

The fire and health hazards are also categorized based on NFPA (National Fire Protection Association) classifications, described in **Table** below-

Table 20: NFPA for MS, HSD, SKO and Naphtha

S. No	PETROLEUM PRODUCT	N_h	N_f	N_r
1.	Motor Spirit (MS)	1	3	0
2.	High Speed Diesel (HSD)	0	2	0
3.	Superior Kerosene Oil (SKO)	0	2	0
4.	Naphtha	1	3	0

N_h - NFPA health hazard factor
N_f - NFPA flammability hazard factor
N_r - NFPA reactivity hazard factor

Table 21: Key Properties of the Material

MATERIAL	FLASH POINT (^{0}C)	IBP-FBP (^{0}C)	DENSITY (KG/M^3)
MS	-38 to -42	30 to 215	720 to 775
HSD	32 to 96	150 to 400	820 to 900
SKO	35 to 65	145 to 300	800 to 850
Naphtha	-21.7	140 to 205	690-780

4.6 Dow Fire & Explosion Index

The major plant element containing hazardous material are the storage tanks, associated pumping/transfer processes through pipeline and tank truck loading. The Fire and Explosion Index is calculated based on the method developed by Dow Chemical Company (USA).

The Fire and Explosion Index F is calculated from

F=MF x (1 +GPHtot) x (1 + SPHtot)

In which

MF = Material Factor, a measure for the potential energy of the dangerous substances present (According to NFPA data)

GPHtot = General Process Hazards, a measure for the hazards inherent in the process (from the nature and characteristics of the process)

SPHtot = Special Process Hazards, a measure for the hazards originating from the specific installation (process conditions, nature and size of installation, etc.)

Evaluation of the hazard based on the F&E Index is done based on the following guidelines:

Table 22: Explanation of NFPA classification

Classification	Definition
Health Hazard	
4	Materials, which on very short exposure could cause death or major residual

	injury even though prompt medical treatments were given.
3	Materials, which on short exposure could cause serious temporary or residual injury even though prompt medical treatments were given.
2	Materials, which on intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment is given.
1	Materials, which on exposure would cause irritation but only minor residual injury even if no treatment is given.
0	Materials, which on exposure under fire conditions would offer no hazard beyond that of ordinary combustible material.
Flammability	
4	Materials which will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature, or which are readily dispersed in air and which will burn readily.
3	Liquids and solids that can be ignited under almost all ambient temperature conditions.
2	Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.
1	Material that must be preheated before ignition can occur.
0	Materials that will not burn.
Reactivity	
4	Materials which in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperature and pressures.
3	Materials which in themselves are capable of detonation or explosive reaction but require a strong initiating source or which must be heated under confinement before initiation or which react explosively with water.
2	Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Also materials which may react violently with water or which may form potentially explosive mixtures with water.

1	Materials which in themselves are normally stable, but which can become unstable at elevated temperature and pressures or which may react with water with some release of energy but not violently.
0	Materials which in themselves are normally stable, even under fire exposure conditions, and which are not reactive with water.

4.7 Characterizing the failures

Accidental release of flammable vapors can result in severe consequences. Delayed ignition of flammable vapors can result in blast overpressures covering large areas. This may lead to extensive loss of life and property. Toxic clouds may cover yet larger distances due to the lower threshold values in relation to those in case of explosive clouds (the lower explosive limits). In contrast, fires have localized consequences. Fires can be put out or contained in most cases; there are few mitigating actions one can take once a vapor cloud is released.

In a petroleum processing installation such as the plant in question, the main hazard arises due to the possibility of leakage of petroleum product during transportation. To formulate a structured approach to identification of hazards and understanding of contributory factors is essential.

4.8 Operating Parameters

4.8.1 Inventory

Inventory Analysis is commonly used in understanding the relative hazards and short listing of release scenarios. Inventory plays an important role in regard to the potential hazard. Larger the inventory of a vessel or a system, larger the quantity of potential release. A practice commonly used to generate an incident list is to consider potential leaks and major releases from fractures of pipelines and vessels containing sizable inventories. Each section is then characterized by the following parameters required for consequence modeling:

- Mass of flammable material in the process/storage section(oil/gas)
- Pressure, Temperature and composition of the material
- Hole size for release

4.8.2 Loss of Containment

Plant inventory can get discharged to Environment due to Loss of Containment. Various causes and modes for such an eventuality have been described. Certain features of materials to be handled at the plant need to the clearly understood to firstly list out all significant release cases and then to short list release scenarios for a detailed examination.

4.8.3 Gas Outflow from a vessel/line

Gas release can be either instantaneous or continuous. Failure of a vessel leading to an instantaneous outflow assumes the sudden appearance of such a major crack that practically all of the contents above the crack shall be released in a very short time. The flow rate will depend on the size of the hole as well as on the pressure in front of the hole, prior to the accident. Such pressure is basically dependent on the pressure in the vessel.

4.8.4 Vaporization

The vaporization of released liquid depends on the vapor pressure and weather conditions.

Such consideration and others have been kept in mind both during the initial listing as well as during the short listing procedure. Initial listing of all significant inventories in the process plants was carried out. This ensured no emission through inadvertence.

Based on the methodology discussed above a set of appropriate scenarios was generated to carry out Risk Analysis calculations for Pool fire, fire ball, source strength, toxic threat zone, flammability threat zone, overpressure (blast force) from vapor cloud explosion.

CHAPTER-5: RELEASE CONSEQUENCE ANALYSIS

5.1 General

Consequence analysis involves the application of the mathematical, analytical and computer models (PHAST software) for calculation of the effects and damages subsequent to a hydrocarbon/toxic release accident.

PHAST (Process Hazard Analysis Software Tools) software developed by DNV GL (A Risk Management Company) is used for risk assessment studies involving flammable and toxic hazards where individual and societal risks are also to be identified. It enables the user to assess the physical effects of accidental releases of toxic or flammable chemicals.

PHAST v7.11 is used for consequence calculations and PHAST Risk Micro v6.7 is used for risk calculations for KSPL Aug Project. It contains a series of up to date models that allow detailed modelling and quantitative assessment of release rate pool evaporation, atmospheric dispersion, vapour cloud explosion, combustion, heat radiation effects from fires etc., The software is developed based on the hazard model given in TNO (as the basis of Yellow Book) models.

PHAST is the industry standard tool for Process Hazard Analysis (PHA). It is used to estimate, understand and visualise the effects from loss of containment scenarios. Applications of PHAST include-

- Plant layout
- Inventory planning
- Pollution control
- Providing input to major accident prevention and safety management planning
- Emergency response plan development
- Safety case preparation
- Compliance with regulations
- Non-standard operations analysis

PHAST software includes latest technical up gradation for carrying out modelling more realistically which includes Unified dispersion modelling, Droplet modelling, CO_2 modelling, and Enhanced models for Long Pipeline Calculations to handle difficult compositions and Time varying discharge enhancements to provide more realistic consequence and risk results.

PHAST Software is used to predict the physical behavior of hazardous incidents. The model uses below mentioned techniques to assess the consequences of identified scenarios:

- Modeling of discharge rates when holes develop in process equipment/pipe work.

- Modeling of the size & shape of the flammable gas clouds from releases in the atmosphere.
- Modeling of the flame and radiation field of the releases that are ignited and burn as pool fire, jet fire, Overpressure (Blast Force) and flash fire.
- Modeling of the explosion fields of releases which are ignited away from the point of release.

The different consequences (Flammable, Jet fire and Overpressure (Blast force) effects) of loss of containment accidents depend on the sequence of events & properties of material released leading to the either flammable area dispersion or Jet fire or Overpressure (Blast Force) or both.

5.2 Consequence Analysis Modeling

5.2.1 Discharge Rate

The initial rate of release through a leak depends mainly on the pressure inside the equipment, size of the hole and phase of the release. The release rate decreases with time as the equipment depressurizes. This reduction depends mainly on the inventory and the action taken to isolate the leak and blow-down the equipment.

5.2.2 Dispersion

Releases of gas into the open air form clouds whose dispersion is governed by the wind, by turbulence around the site, the density of the gas and initial momentum of the release. In case of flammable materials the sizes of these gas clouds above their Lower Flammable Limit (LFL) are important in determining whether the release will ignite. In this study, the results of dispersion modeling for flammable materials are presented LFL quantity.

5.2.3 Flash Fire

A flash fire occurs when a cloud of vapors/gas burns without generating any significant overpressure. The cloud is typically ignited on its edge, remote from-the leak source. The combustion zone moves through the cloud away from the ignition point. The duration of the flash fire is relatively short but it may stabilize as a continuous jet fire from the leak source. For flash fires, an approximate estimate for the extent of the total effect zone is the area over which the cloud is above the LFL.

5.2.4 Jet Fire

Jet fires are burning jets of gas whose shape is dominated by the momentum of the release. The jet flame stabilizes on or close to the point of release and continues until the release is stopped. Jet fire can be realized, if the leakage is immediately ignited. The effect of jet flame

impingement is severe as it may cut through equipment, pipeline or structure. The damage effect of thermal radiation is depended on both the level of thermal radiation and duration of exposure.

5.2.5 Pool Fire

A cylindrical shape of the pool fire is presumed. Pool-fire calculations are then carried out as part of an accidental scenario, e.g. in case a hydrocarbon liquid leak from a vessel leads to the formation of an ignitable liquid pool. First no ignition is assumed, and pool evaporation and dispersion calculations are being carried out. Subsequently late pool fires (ignition following spreading of liquid pool) are considered. If the release is bounded, the diameter is given by the size of the bund. If there is no bund, then the diameter is that which corresponds with a minimum pool thickness, set by the type of surface on which the pool is spreading.

While modeling cases of lighter hydrocarbons in the range of naphtha and MS (motor spirit) wherein the rainout fraction have been minimal (not leading to pool formation) due to the horizontal direction of release, downward impingement has been considered for studying the effects of pool fire for consequence analysis only.

Pool fires occur when spilled hydrocarbons burn in the form of large diffusion flames. Calculating the incident flux to an observer involves four steps, namely

- Characterizing the flame geometry
- Estimation of the flame radiation properties
- Computation of the geometric view factors
- Estimation of flame attenuation coefficients and computation of geometric view factors between observer and flame.

The size of the flame will depend upon the spill surface and the thermo chemical properties of the spilled liquid. In particular, the diameter of the fire, the visible height of the flame, the tilt and drag of the flame etc. The radioactive output of the flame will depend upon the fire size, the extent of mixing with air and the flame temperature. Some fraction of the thermal radiation is absorbed by the carbon dioxide and water vapor in the intervening atmosphere. In addition, large hydrocarbon fires produce thick smoke which significantly obscure flame radiation.
The calculations for radiation damage distances start with estimation of the burning velocity:

$Y= 92.6\ e - 0.0043T_bMw10^{-7}/ (D\ X\ 6)$

Where, Y= burning velocity in m/s
Mw= molecular weight in kg/kg mol
T_b= normal boiling point
D= Density in kg/m^3
The next step involves calculation of the equivalent diameter for the spreading pool- this depends

upon the duration of the spill (continuous, instantaneous, finite duration etc.). This is calculated using expressions like:

$D_{eq}. = 2(V/3.142y)^{1/2}$

Where, $D_{eq}.$ = steady state diameter of the pool in m
V= liquid spill rate in m^3/s
y= Liquid burning rate in m/s

In the absence of frictional resistance during spreading, the equilibrium diameter is reached over a time given by:

$T_{eq}. = 0.949\ D_{eq}./(\Delta\ y\ X\ D_{eq}.)^{1/3}$

The visible flame height is given by;

$H_{flame} = 42D_p\ ((BvD/D_a(gD_p)1/2)^{0.61}$
Where H_{flame} = flame height in m
D= density in kg/m^3
D_a= air density in kg/m^3
g = gravitational acceleration or 9.81 m/s^2
Δy= burning rate (difference between final and initial burning rate)

The emissive power of a large turbulent fire is a function of the black body emissive power and the flame emissivity. The black body emissive power can be computed by Planck's law of radiation. The general equation used for the calculation is:

$E_P = -0.313T_b + 117$

Where E_p is the effective emissive power in kw/m^2

T_b= normal boiling point of the liquid in °F

Materials with a boiling point above 30 °F typically burn with sooty flames-the emissive power from the sooty section is about 20 kW $/m^2$. The incident flux at any given location is given by the equation:

$Q_{incident} = EP * t * V_F$

Where, $Q_{incident}$ = incident flux in kw/m^2
t= transmitivity (a function of path length, relative humidity and flame temperature) often taken as 1 and the attenuation of thermal flux due to atmospheric absorption ignored.

V_F= geometric view factor

The view factor defines the fraction of the flame that is seen by a given observer.

$V_F = 1.143 (R_p/X) 1.757$

Where, X= distance from the flame center in m
R_p= pool radius in m

Based on the radiation received, the fatality levels are calculated from Probit equation, which for protected clothing is given by:

$Pr. = -37.23 + 2.56 \ln (t \times Q^{4/3})$

Where, Pr. = Probit No.
t= time in seconds
Q heat radiation in w/m^2

5.2.6 Blast Overpressures

Blast Overpressures depend upon the reactivity class of material and the amount of gas between two explosive limits. Motor Spirit (MS) could give rise to a Vapour Cloud Explosion (VCE) due to their vapor pressures - however, as the results will indicate, the cloud flammable masses are quite small due to the high boiling point and low vapor pressures. In addition, unless there is sufficient extent of confinement, it is unlikely to result in any major explosion. Examples where flammable mixtures could be found are within storage tanks and road tankers. Open-air explosions are unlikely. As a result, damage would be limited.

Equations governing the formation of overpressures in an explosion are given later. Blast overpressures are calculated based on comparison of combustion energy per unit mass of a vapor cloud with that of TNT and taking into account that only a fraction of the energy will contribute to the explosion. Overpressure data compiled from measurements on TNT are used to relate overpressure data to distance from explosions. The equivalent mass of TNT is calculated using the equations:

$M_{TNT} = (M_{cloud} \times (\Delta H_c.)/1155 \times Y_f)$
Where M_{TNT} is the TNT equivalent mass (lb)
ΔH_c = Heat of combustion is in Kcals/kg
M_{cloud} is mass in cloud in lbs
Y_f is the yield factor

The distance to a given overpressure is calculated from the general equation:

$$X=M_{TNT}\ 1/3 \exp (3.5031-0.7241 \ln (O_p) + 0.0398 (\ln O_p))^2$$

Where X is the distance to a given overpressure in feet
O_p is the peak overpressure

5.2.7 Toxic Release

The aim of the toxic risk study is to determine whether the operators in the plant, people occupied buildings and the public are likely to be affected by toxic substances. Toxic gas cloud e.g. H_2S, chlorine, etc was undertaken to the Immediately Dangerous to Life and Health concentration (IDLH) limit to determine the extent of the toxic hazard created as the result of loss of containment of a toxic substance.

5.3 Size and Duration of Release

Leak size considered for selected failure cases are as listed in **Table** below-

Table 23: Leak size of selected failure scenario

Failure Description	Leak Size
Pump seal failure	6 mm hole size
Flange gasket failure	10 mm hole size
Leak in tank/pipeline	10 mm hole size
Small hole	20 mm hole size
Large hole	50 mm hole size
Catastrophic failure	Complete rupture of equipment

The duration of release is a very important input to the consequence analysis as this directly dictates the quantity of material released. General basis for deciding the duration of release is given in the **Table** below-

Table 24: Duration of release

Blocking system configuration	Isolation Time(m)
Fully automatic blocking system(including automatic detection and closure of block valves)	2
For remote operated blocking systems (detection is automatic, but control room operator must validate alarm signal and close block valve remotely)	10
For hand-operated blocking systems (detection is automatic, but control room operator must validate alarm, go to field and manually close block valve)	30

The discharge duration is taken as 10 minutes for continuous release scenarios as it is considered that it would take plant personnel about 10 minutes to detect and isolate the leak.

5.4 Damage Criteria

In order to appreciate the damage effect produced by various scenarios, physiological/physical effects of the blast wave, thermal radiation or toxic vapor exposition are discussed.

5.4.1 LFL or Flash Fire

Hydrocarbon vapor released accidentally will spread out in the direction of wind. If a source of ignition finds an ignition source before being dispersed below lower flammability limit (LFL), a flash fire is likely to occur and the flame will travel back to the source of leak. Any person caught in the flash fire is likely to suffer fatal burn injury. Therefore, in consequence analysis, the distance of LFL value is usually taken to indicate the area, which may be affected by the flash fire.

Flash fire (LFL) events are considered to cause direct harm to the population present within the flammability range of the cloud. Fire escalation from flash fire such that process or storage equipment or building may be affected is considered unlikely.

5.4.2 Thermal Hazard Due to Jet Fire and Pool Fire

Thermal radiation due to jet fire and pool fire may cause various degree of burn on human body and process equipment. The following table details the damage caused by various thermal radiation intensity.

Table 25: Effects due to incident radiation intensity

Incident Radiation (kW/m^2)	Type of Damage
0.7	Equivalent to Solar Radiation
1.6	No discomfort for long exposure
4.0	Sufficient to cause pain within 20 sec. Blistering of skin (first degree burns are likely)
9.5	Pain threshold reached after 8 sec. Second degree burns after 20 sec.
12.5	Minimum energy required for piloted ignition of wood, melting plastic tubing etc.
25	Minimum energy required to ignite wood at indefinitely long exposure
37.5	Sufficient to cause damage to process equipment

Source: Major Hazard Control, ILO

5.4.3 Vapor Cloud Explosion

In the event of explosion taking place within the plant, the resultant blast wave will have damaging effects on equipment, structures, building and piping falling within the overpressure distances of the blast. Tanks, buildings, structures etc. can only tolerate low level of overpressure. Human body, by comparison, can withstand higher overpressure. But injury or fatality can be inflicted by collapse of building of structures. The following table illustrates the damage effect of blast overpressure.

Table 26: Damage due to Overpressures

Peak Overpressure	Damage Type
12.04 psi	Total Destruction
4.35 psi	Heavy Damage
1.45 psi	Moderate Damage
0.44 psi	Significant Damage
0.15 psi	Minor Damage

5.5 Generic Failure Rate Data

Generic leak frequency data published by International Association of Oil and gas Producers (OGP) are used in this RA study. An extract from OGP Risk assessment data directory- report no.434 (March-2010) used in present study is reported in the **Table** below-

Table 27: Failure frequency (OGP Data)

Equipment overall failure frequency(per year)						
Equipment Name	**Minor Leak**	**Medium Leak**		**Major Leak**	**Full bore Rupture**	**Total**
	[3mm]	**[10mm]**	**[25mm]**	**[100mm]**	**[>100mm]**	
Process Pipe <2”	9.00×10^{-05}	3.80×10^{-05}	2.70×10^{-05}	-	-	1.6×10^{-04}
Process Pipe <6”	4.10×10^{-05}	1.70×10^{-05}	7.40×10^{-06}	7.60×10^{-06}	-	7.30×10^{-05}
Process Pipe <12”	3.70×10^{-05}	1.60×10^{-05}	6.70×10^{-06}	1.40×10^{-06}	5.90×10^{-06}	6.70×10^{-05}
Process Pipe 18”	3.60×10^{-05}	1.50×10^{-05}	6.50×10^{-06}	1.40×10^{-06}	5.90×10^{-06}	6.50×10^{-05}
Flanges<2”	4.40×10^{-05}	1.80×10^{-05}	1.50×10^{-05}	-	-	7.70×10^{-05}
Flanges<6”	6.50×10^{-05}	2.60×10^{-05}	1.10×10^{-05}	8.50×10^{-06}	-	1.10×10^{-04}
Flanges<12”	9.60×10^{-05}	3.90×10^{-05}	1.60×10^{-05}	3.20×10^{-06}	7.00×10^{-06}	1.60×10^{-04}
Manual Valves<2”	4.40×10^{-05}	2.30×10^{-05}	2.10×10^{-05}	-	-	8.80×10^{-05}
Manual Valves<6”	6.60×10^{-05}	3.40×10^{-05}	1.80×10^{-05}	1.10×10^{-05}	-	1.30×10^{-04}
Manual Valves<12”	8.40×10^{-05}	4.30×10^{-05}	2.30×10^{-05}	6.30×10^{-06}	7.80×10^{-06}	1.60×10^{-04}
Actuated Valves<2”	4.20×10^{-04}	1.80×10^{-04}	1.10×10^{-04}	-	-	7.10×10^{-04}
Actuated Valves<6”	3.60×10^{-04}	1.50×10^{-04}	6.60×10^{-05}	3.30×10^{-05}	-	6.10×10^{-04}
Actuated Valves<12”	3.30×10^{-04}	1.40×10^{-04}	6.00×10^{-05}	1.30×10^{-05}	1.80×10^{-05}	5.60×10^{-04}
Instrument Connections	3.50×10^{-04}	1.50×10^{-04}	6.50×10^{-05}	-	-	5.60×10^{-04}
Pumps-Centrifugal	5.10×10^{-03}	1.80×10^{-03}	5.90×10^{-04}	1.40×10^{-04}	-	7.60×10^{-03}
Compressor - Reciprocating	4.50×10^{-02}	1.70×10^{-02}	6.70×10^{-03}	2.00×10^{-03}	-	7.10×10^{-02}

5.6 Plant Data

RA study conducted is based on the data available from current engineering documents developed for the Station/terminal. These documents are given in **Table** below-

Table 28: List of documents used in study

S. No.	Location (Station/Terminal)	Document / Drawing Title	Document / Drawing No.
1.	Koyali	General Layout Plan at Koyali for KSPL Aug Project	9200-10301-302-001-00
2.	Viramgam	General Layout Plan of Viramgam Pump Station	9200-09505-202-051-00
3.	Sidhpur	General Layout Plan for Sidhpur Pump Station	9200-10305-302-001-00
4.	Kot	General Layout Plan for Kot Pump Station (KSPL Aug PJ)	9200-10307-302-001-00

5.7 Consequence analysis for Station/Terminal

5.7.1 Scenarios

The scenarios for consequence analysis have been identified as listed in **Table** below-

Consequence analysis results

Results of the consequence analysis for the scenarios covered in this study are summarized in **Table** below**.** Major contributing Scenario to societal risk from Station/terminal consequence analysis graphs are attached as **ANNEXURE A.**

Table 29: Consequence Analysis – Scenario result

Weather: 5D

Case	Flammable area of vapour cloud (m)			Jet Fire (m)			Pool Fire (m)			Overpressure (blast force) from vapor cloud explosion (m)			Flash fire (m)	
	UFL	LFL	LFL fraction	4 (kW/m^2)	12.5(kW/m^2)	37.5(kW/m^2)	4 (kW/m^2)	12.5(kW/m^2)	37.5(kW/m^2)					
	76800 ppm	10500 ppm	5250 ppm							0.02068 bar	0.1379 bar	0.2068 bar	10500 ppm	5250 ppm
Leakage from Pipeline at Kot	3	8	17	21	15	12	N.R	N.R	N.R	36	15	14	8	17
Rupture from Pipeline at Kot	18	40	49	NR	NR	NR	28	24	20	71	45	43	40	49
Leakage in Kot Line balancing tank(LBT)	3	9	18	15	12	9	18	13	8	N.R	N.R	N.R	9	18
Fix Duration Release(LBT) at Kot	5	18	31	27	21	17	49	27	13	N.R	N.R	N.R	18	31
Leakage from Pipeline at Sidhpur	3	5	8	20	15	13	9	8	6	N.R	N.R	N.R	5	8
Rupture from Pipeline at Sidhpur	6	15	19	NR	NR	NR	10	8	6	N.R	N.R	N.R	15	19

Case	Flammable area of vapour cloud (m)			Jet Fire (m)			Pool Fire (m)			Overpressure (blast force) from vapor cloud explosion (m)			Flash fire (m)	
	UFL	LFL	LFL fraction	4 (kW/m^2)	12.5(kW/m^2)	37.5(kW/m^2)	4 (kW/m^2)	12.5(kW/m^2)	37.5(kW/m^2)					
	76800 ppm	10500 ppm	5250 ppm							0.02068 bar	0.1379 bar	0.2068 bar	10500 ppm	5250 ppm
Leakage from Pipeline at Viramgam	4	19	35	30	22	18	33	24	16	79	39	37	19	35
Rupture from Pipeline at Viramgam	9	48	72	N.R	N.R	N.R	49	23	N.R	223	78	72	48	72
Leakage from Pipeline at Koyali	4	19	35	31	23	18	17	15	14	25	20	15	19	35
Rupture from Pipeline at Koyali	9	48	72	N.R	N.R	N.R	49	23	N.R	223	78	72	48	72

N.R - Not Reached

CHAPTER-6: RISK ANALYSIS

6.1 Individual Risk

The results of Risk Analysis are often reproduced as Individual Risk. Individual Risk is the probability of death occurring as a result of accidents at a fixed installation or a transport route expressed as a function of the distance from such an activity.

There are no specified risk acceptance criteria as yet in our country for Individual Risk levels. A review of risk acceptance criteria in use in other countries indicates the following:

- For fixed installations Official Individual Risk Criteria have been developed by various countries and the review indicates that Individual Risk of fatality to the members of the public outside the installation boundaries may be adopted as higher 1E-05 per year (in populated areas) for intolerable risk and lower than 1E-06 per year for negligible risk. The region in between is the so-called ALARP region where risk is acceptable subject to its being **A**s **L**ow **A**s **R**easonably **P**racticable (The ALARP principle).
- The individual risk results show the geographical distribution of risk. It is the frequency at which an individual may be expected to sustain a given level of harm from the realization of specified hazards and is normally taken as risk of death (fatality). It is expressed as risk per year.
- Individual risk is usually presented in the form of Individual Risk Contours, which are also commonly known as ISO Risk Curves. This is the risk to a hypothetical individual being present at that location continuously there for 24 hours a day and 365 days a year.

6.1.1 Individual Risk Acceptability Criteria

As per IS15656:2006 Indian Standard code of practice on hazard identification & Risk analysis, in many countries the acceptable risk criteria has been defined for the industrial installations and are shown in **Table** below-

Table 30: Acceptable Risk Criteria of various countries

Authority and Application	Maximum tolerable risk (per year)	Negligible risk (per year)
VROM, the Netherlands (New)	$1 X 10^{-6}$	$1 X 10^{-8}$
VROM, the Netherlands (Existing)	$1 X 10^{-5}$	$1 X 10^{-8}$
HSE, UK (Existing hazardous industries)	$1 X 10^{-4}$	$1 X 10^{-6}$
HSE, UK (Nuclear power station)	$1 X 10^{-5}$	$1 X 10^{-6}$
HSE, UK (Substance transport)	$1 X 10^{-4}$	$1 X 10^{-6}$
HSE, UK (New Housing near plants)	$3 X 10^{-5}$	$3 X 10^{-7}$
Hong Kong Government (new plants)	$1 X 10^{-5}$	Not Used

Since there are no guidelines on the tolerability of fatality risk sanctioned in India to date, to demonstrate the risk to employee and public the following are considered.

- If the average expectation of life is about 75 years, then the imposition of an annual risk of death to individual is 0.01 (one in one hundred years), it seems unacceptable. Hence 1 in 1000 years, it may not be totally unacceptable if the individual knows of the situation, has been considered as upper limit of the ALARP triangle for people working inside the Station/terminal complex.
- Lower limit of ALARP triangle is taken as $1 X 10^{-05}$ per year for people working inside the Station/Terminal complex.
- Upper limit of tolerable risk to a member of general public is taken as $1 X 10^{-03}$ per year.
- Similarly, $1 X 10^{-06}$ per year (Negligible risk) is considered for public to demonstrate the risk. This is the lower limit of the ALARP triangle.

The Individual Risk per Annum levels discussed above is demonstrated graphically in the so called “ALARP triangle” represented in Figure below. In the lower region, the risk is considered negligible, provided that normal precautions are maintained. The upper region represents an intolerable risk must be reduced. The area between these two levels is the “ALARP Region (As Low As Reasonably Practicable)” in which there is a requirement to apply ALARP principle. Any risk that lies between intolerable and negligible levels should be reduced to a level which is “As Low As Reasonably Practicable”.

For Transportation facilities, the Risk tolerability criteria as set in the ACDS *Transport Hazards Report* published by the HSE of the UK adopts fatality risk $1X10^{-03}$ per year as ‘intolerable’

while fatality risk of 1 X 10^{-06} per year is adopted as 'broadly acceptable'. The ALARP principle then implies that if the fatality risk from a particular transport activity lies between 1 X 10^{-06} per year and 1 X 10^{-03} per year, then efforts should be made to reduce to it to as low a level as reasonably practicable.

The individual risks from an activity are the result of the cumulative of risks connected with all possible scenarios.
The individual risk results show the geographical distribution of risk. It is the frequency at which an individual may be expected to sustain a given level of harm from the realization of specified hazards and is normally taken as risk of death (fatality). It is expressed as risk per year.

In case of Station/Terminal, the Individual Risk Contours run close to the plant. The overall worst case scenario for Stations Koyali, Viramgam, Sidhpur and Kot are given in Figures below-

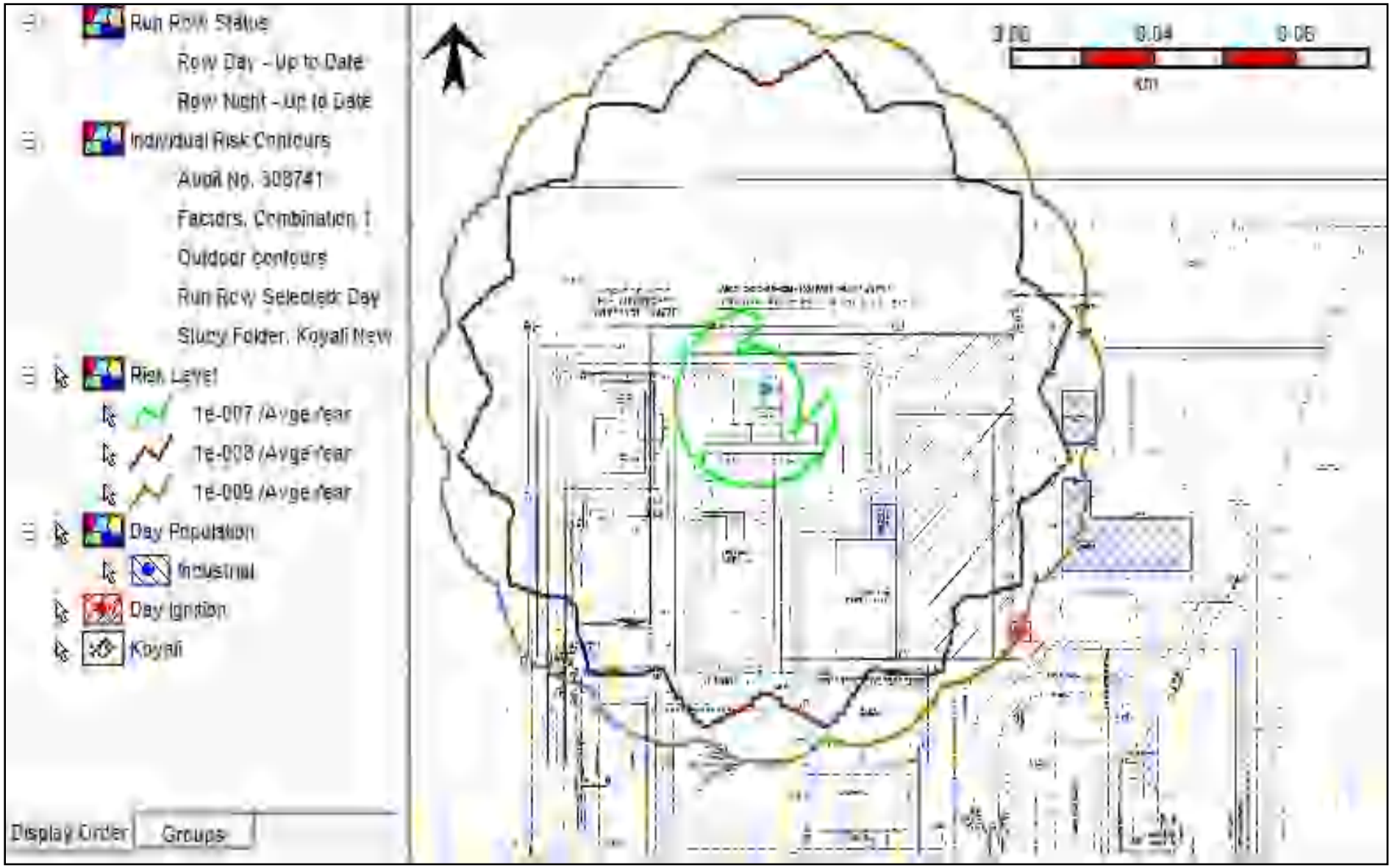


Figure 12:- Graph showing worst case scenario for KSPL Aug (Koyali)

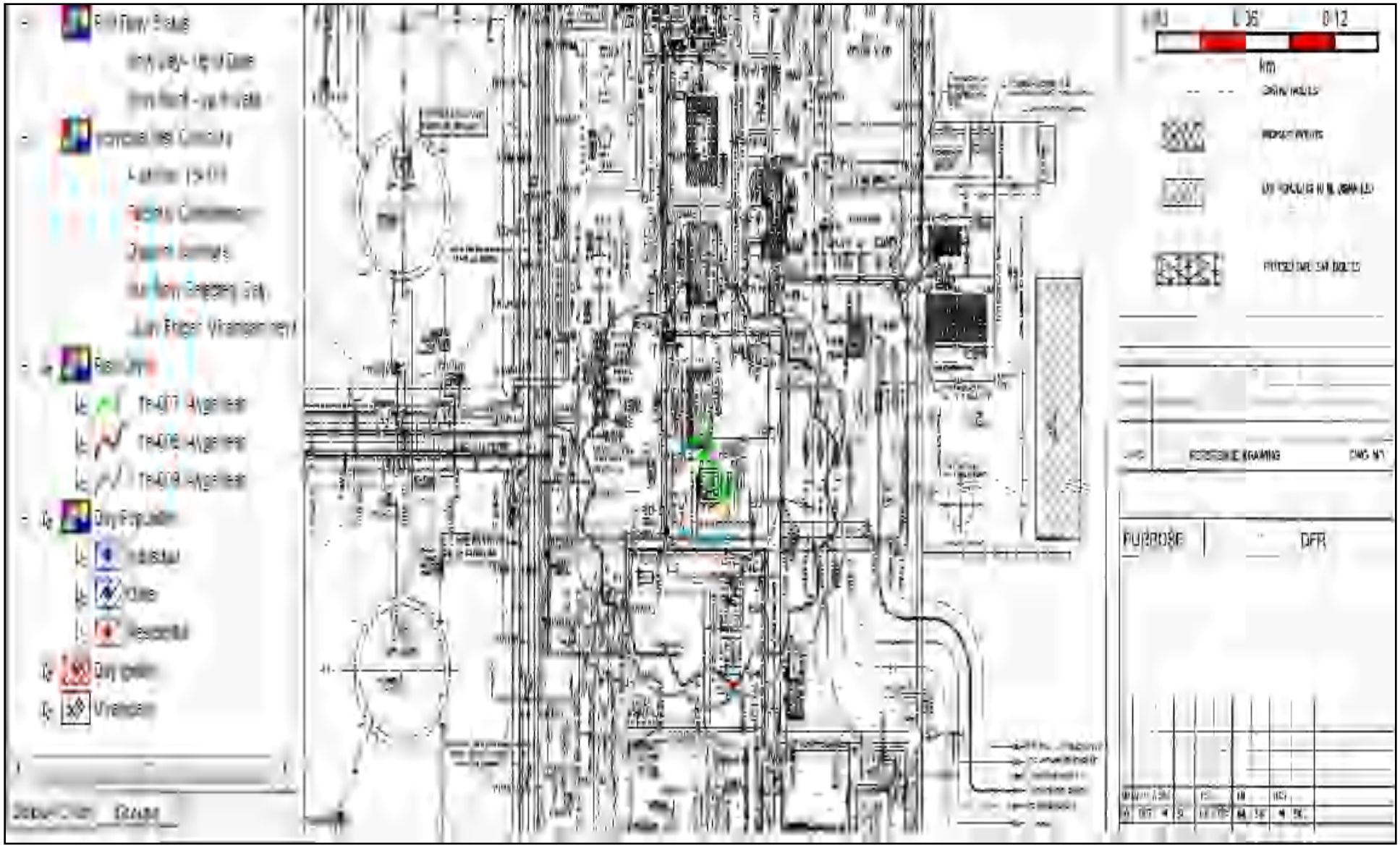


Figure 13:- Graph showing worst case scenario for KSPL Aug (Viramgam)

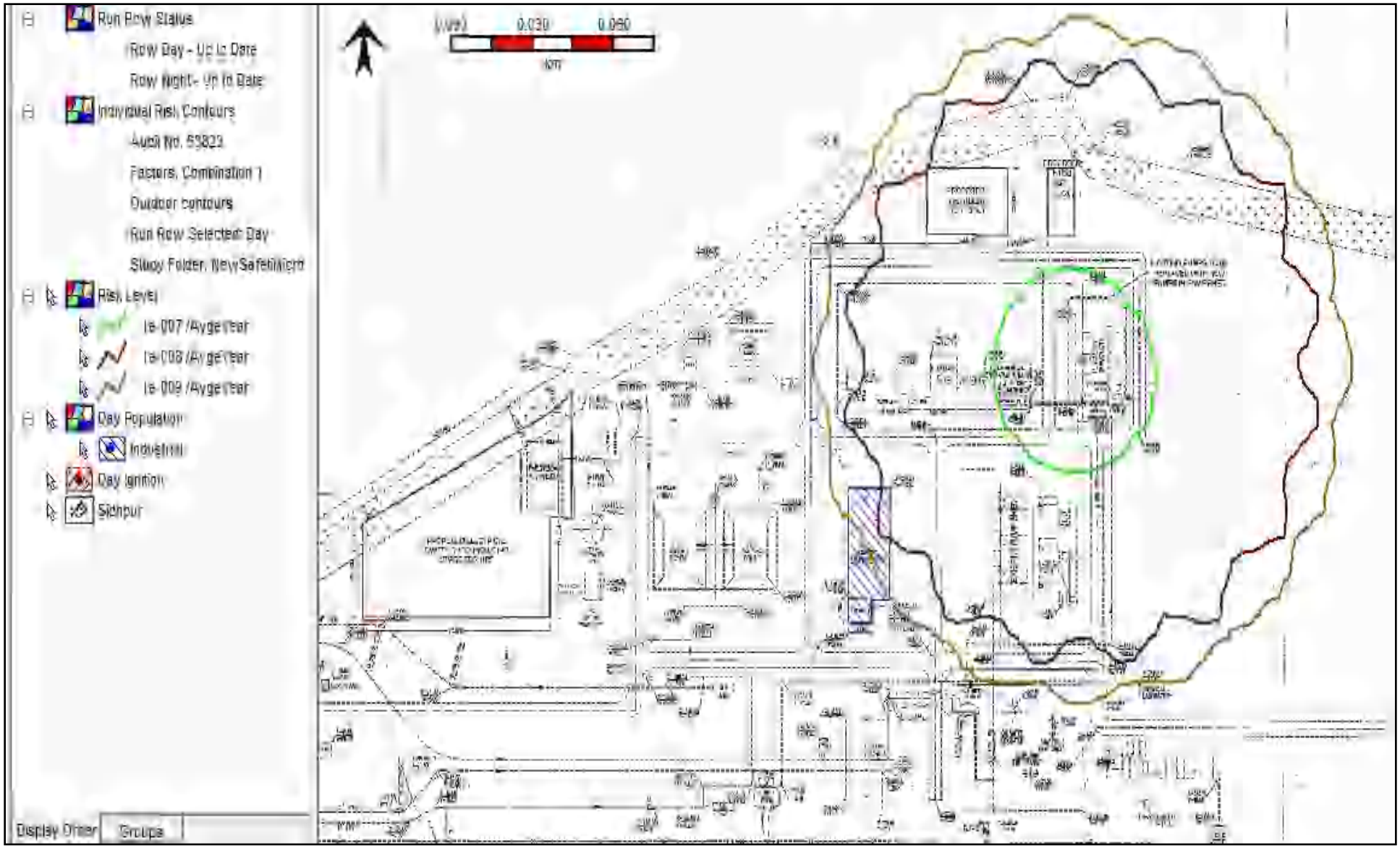


Figure 14:- Graph showing worst case scenario for KSPL Aug (Sidhpur)

Figure 15:- Graph showing worst case scenario for KSPL Aug (Kot)

6.1.2 Location Specific Individual Risk (LSIR)

The highest location-specific individual risk (LSIR) contour in Station/terminal is of 1 X 10^{-09} per year which is below the ALARP region.

The maximum LSIR in the unit are listed in **Table** below-

Table 31: Maximum LSIR at Station/Terminal

S. No.	Unit	Maximum LSIR
1.	Koyali Station Control room	1 X 10^{-08} per year
2.	Viramgam Station Control room	1 X 10^{-09} per year
3.	Sidhpur Station Control room	1 X 10^{-08} per year
4.	Kot Station Control room	1 X 10^{-08} per year

6.1.3 Individual Specific Individual Risk (ISIR)

Individual risk to worker at Station/terminal calculated as a person who is standing at that point 365 days a year and 24 hours a day. The people in plant are expected to work in 8 hour shift as well general shift. The actual risk to a person "Individual Specific Individual Risk" (ISIR) would be far less after accounting the time fraction a person spent at location.

$ISIR_{Area} = LSIR \times (8/24)_{(8\ hours\ shift)} \times$ (Time spend by an individual / 8 hours)

The comparison of maximum individual risk with risk acceptability criteria is given in Table below-

Table 32: Maximum Individual Specific Individual Risk (ISIR) at Stations

S. No.	Unit	Maximum ISIR
1.	Koyali Station Control room	3.33 X 10^{-09} per year
2.	Viramgam Station Control room	3.33 X 10^{-10} per year
3.	Sidhpur Station Control room	3.33 X 10^{-09} per year
4.	Kot Station Control room	3.33 X 10^{-09} per year

ALARP summary & comparison of Individual risk with acceptability criteria.

The objective of this RA study is to assess the risk levels at Koyali station (Koyali, Virmagam, Sidhpur and Kot Stations) with reference to the defined risk acceptability criteria and recommend measures to reduce the risk level to as low as reasonably practicable (ALARP).

The comparison of maximum individual risk with the risk acceptability criteria is shown in Figure below.

From the results shown above, the maximum individual risk to terminal/station personnel from KSPL Aug estimated as 1 X 10^{-09} per year is lower part of ALARP region.

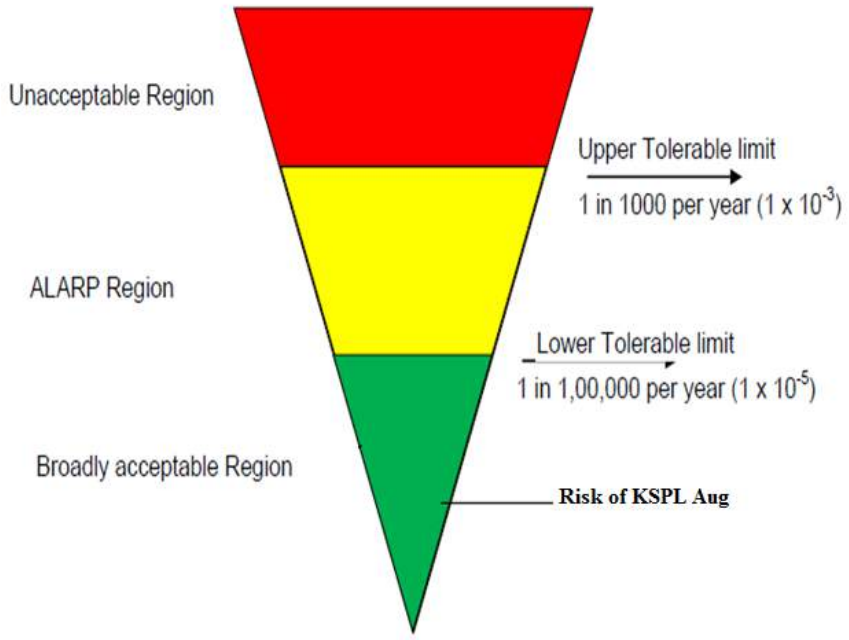


Figure 16:- Individual risk at KSPL Aug (Koyali, Virmagam, Sidhpur and Kot Stations)

6.2 Societal Risk

It is the risk experience in a given time period by the whole group of personnel exposed, reflecting the severity of the hazard and the number of people in proximity to it. It is defined as the relationship between the frequency and the number of people suffering a given level of harm (normally taken to refer to risk of death) from the realization of the specified hazards. It is expressed in the form of F-N curve.

Societal risk acceptability criteria

A formal risk criterion is used at all for societal risk; the criterion most commonly used is the F-N curve. Like other forms of risk criterion, the F-N curve may be cast in the form of a single

criterion curve or of two criterion curves dividing the space in to three regions – where the risk is unacceptable, where it is negligible and where it requires further assessment. The latter approach corresponds to application to societal risk of the ALARP principle. Risk criteria for the Netherlands have been considered for the present study. F-N curve of the stations are represented in **Figure** below-

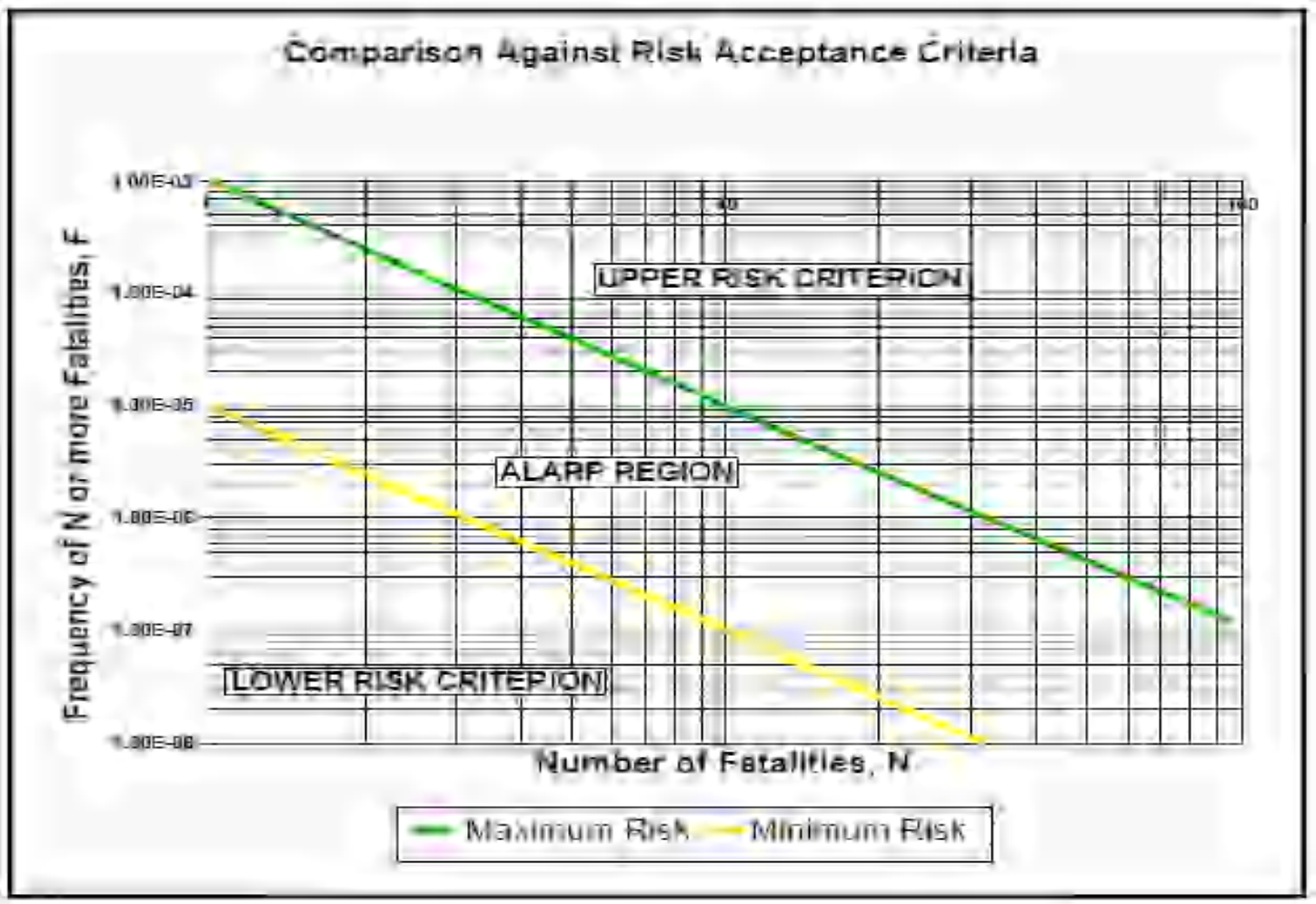


Figure 17:- Societal Risk Criteria

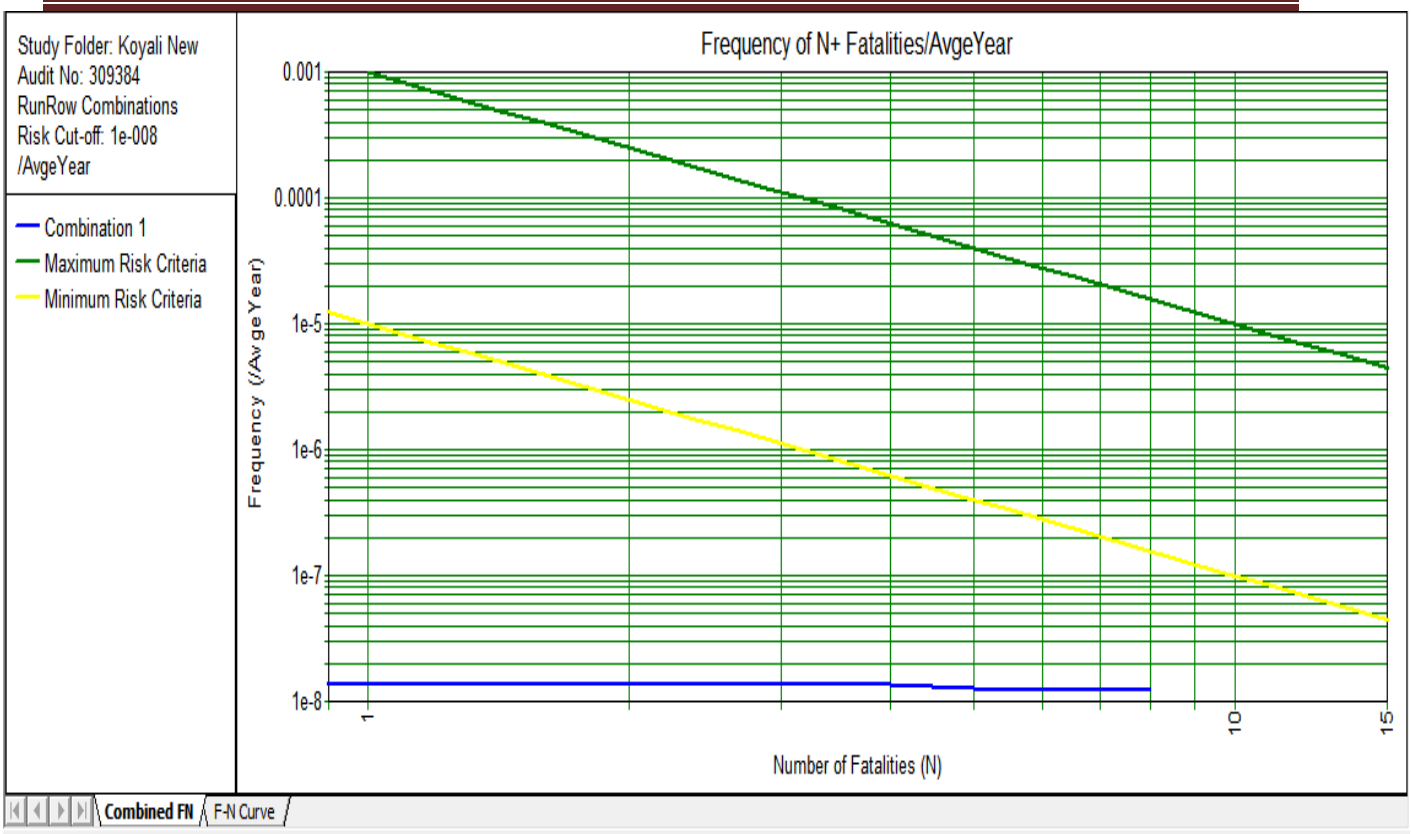


Figure 18:- F-N Curve for Group Risk of Koyali Station

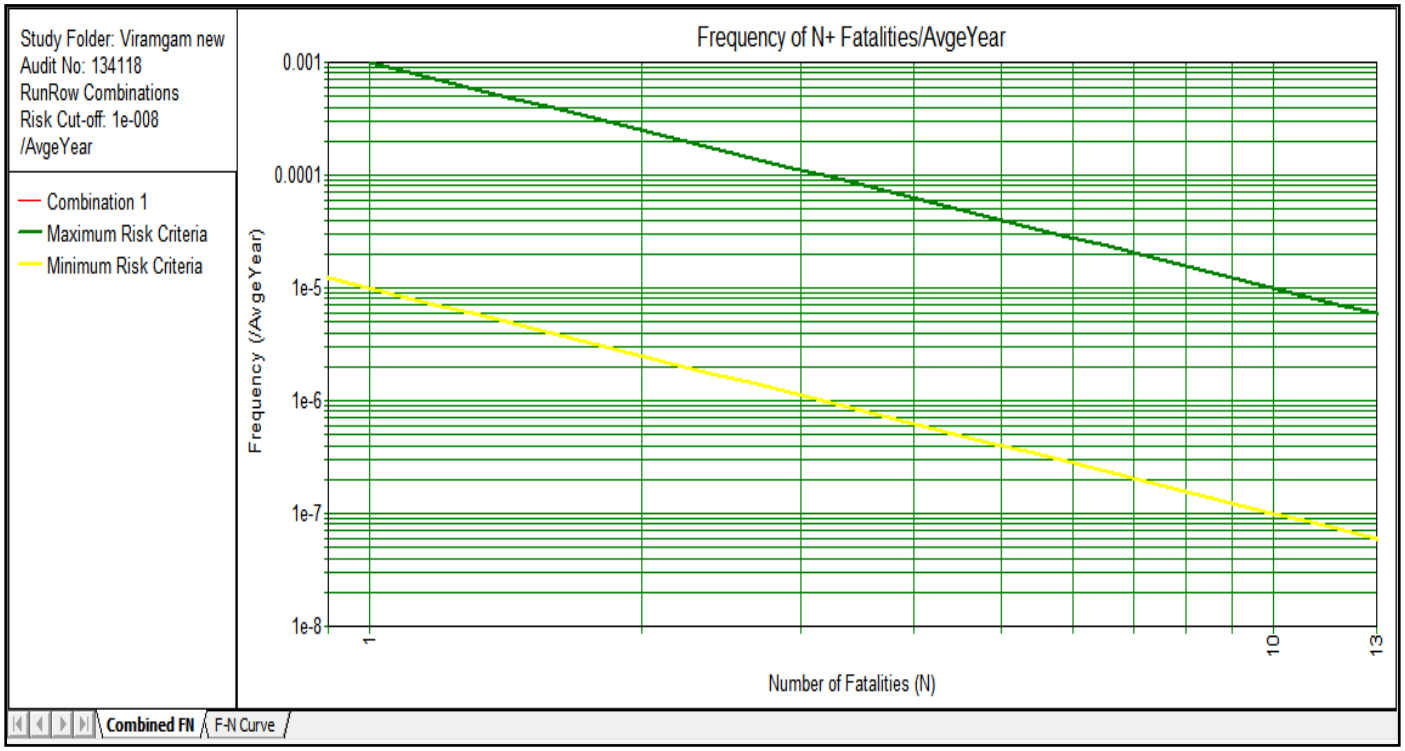


Figure 19:- F-N Curve for Group Risk of Viramgam Station

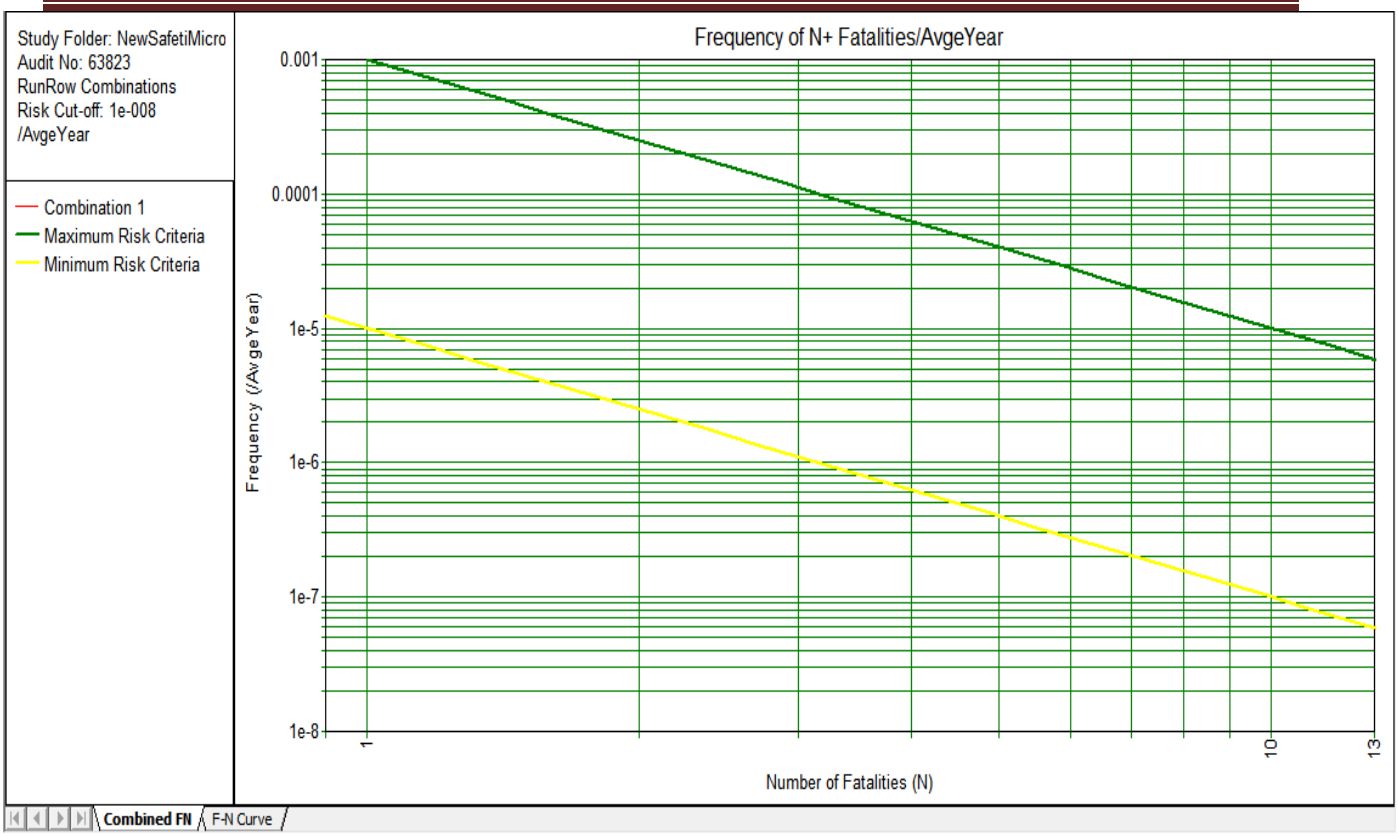


Figure 20:- F-N Curve for Group Risk of Sidhpur Station

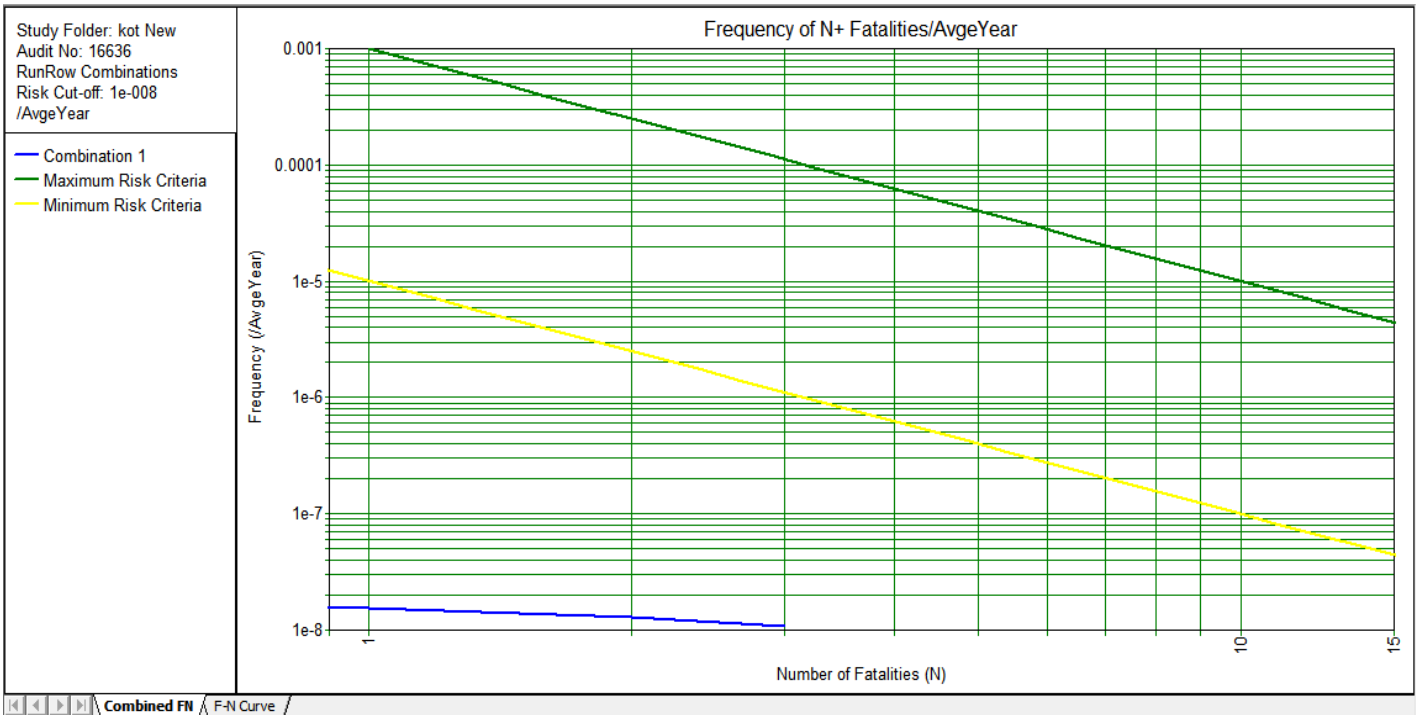


Figure 21:- F-N Curve for Group Risk of Kot Station

Top risk contributors (Societal risk)

The presents major contributing scenarios to societal risk form Station/terminal are broadly acceptable as it is lower part of ALARP region.

6.3 Fault Tree Analysis

Graphical representation of the logical structure displaying the relationship between an undesired potential event (top event) and all its probable causes-

- Top-down approach to failure analysis
- Starting with a potential undesirable event-top event
- Determining all the ways in which it can occur
- Mitigation measures can be developed to minimize the probability of the undesired event.

6.3.1 Fault Tree can help to

The following are the benefits of fault tree analysis.

- Quantifying probability of top event occurrence
- Evaluating proposed system architecture attributes
- Assessing design modifications and identify areas requiring attention
- Complying with qualitative and quantitative safety/reliability objectives
- Qualitatively illustrate failure condition classification of a top-level event
- Establishing maintenance tasks and intervals from safety/reliability assessments.

6.3.2 Fault tree construction

The following gates are used while construction of fault tree for a given process. The meaning and purpose of these are given in the below table-

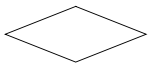
	**AND gate** The AND-gate is used to show that the output event occurs only if all the input events occur
	**OR gate** The OR-gate is used to show that the output event occurs only if one or more of the input events occur
	**Basic event** A basic event requires no further development because the appropriate limit of resolution has been reached
	**Intermediate event** A fault tree event occurs because of one or more antecedent causes acting through logic gates have occurred
	**Transfer** A triangle indicates that the tree is developed further at the occurrence of the corresponding transfer symbol
	**Undeveloped event** A diamond is used to define an event which is not further developed either because it is of insufficient consequence or because information is unavailable

Figure 22:- Fault Tree Construction

6.3.3 Guidelines for developing a fault tree

Following guidelines are to be kept in mind while developing fault tree-

- Classify an event into more elementary events.
- Replace an abstract event by a less abstract event.
- Identify distinct causes for an event.
- Couple trigger event with ‘no protective action’.
- Find co-operative causes for an event.
- Pinpoint a component failure event.

Below diagram shows the fault tree for the Project.

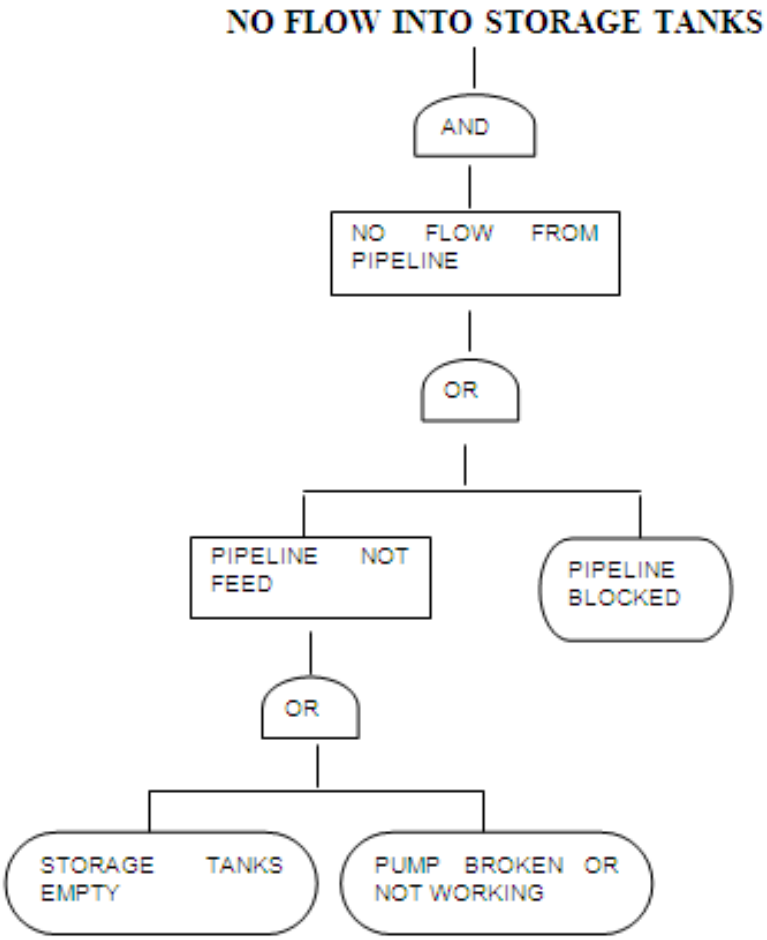


Figure 23:- Fault Tree for the Project

6.4 Event Tree Analysis

An event tree is used to develop the various event outcome of a release and thereby estimate the result event frequency. An event tree is constructed by defining an initial event and the possible consequences that flow from this. The initial event is usually placed on the left and the branches are drawn to the right, each branch representing a different sequence of events and terminating in an outcome.

Each branch of the event tree represents a particular scenario. The tree is a means of estimating the frequency of the outcome for that scenario. For example, for a flammable release, a typical series of models are gas dispersion, ignition, jet fire, pool fire and explosion.

The data used in Event tree analysis are discussed below:

6.4.1 Immediate Ignition

This is the probability that the release ignites immediately, at the release point, before the cloud has begun to disperse and to reach ignition sources away from the release point.

6.4.2 Delayed Ignition

The immediate ignition outcomes are defined to occur with precisely the probability defined by the event tree probabilities. On the other hand the delayed ignition outcomes occur at a frequency calculated by available ignition sources which are fired heater, ignition due to vehicle movement, general ignition (canteen, smoking booth), high tension line etc. The outcome of the delayed ignition of released hydrocarbon results in flash fire or explosion. An un-ignited release will normally disperse with little or no consequence (unless the gas is toxic), whereas a fire or explosion can potentially escalate to endanger the whole installation.

6.4.3 Explosion

The ignition of a free gas cloud may result in both explosion and flash-fire upon ignition. This is modeled as two separate events: as a pure flash fire and a pure explosion. The fraction that is modeled as an explosion has been considered as 0.42.

6.4.4 Materials that is both flammable and toxic

In reality the risk to personnel for a given event could be the result of toxic or flammable effects or combination of the two depending on the properties of the materials being released. Common examples of such flammable and toxic materials include hydrogen sulphide and hydrogen with lighter hydrocarbon (recycle gas section of hydro-treater). In such scenario, non-ignition probability shall be used to define the frequency of a subsequent toxic calculation.

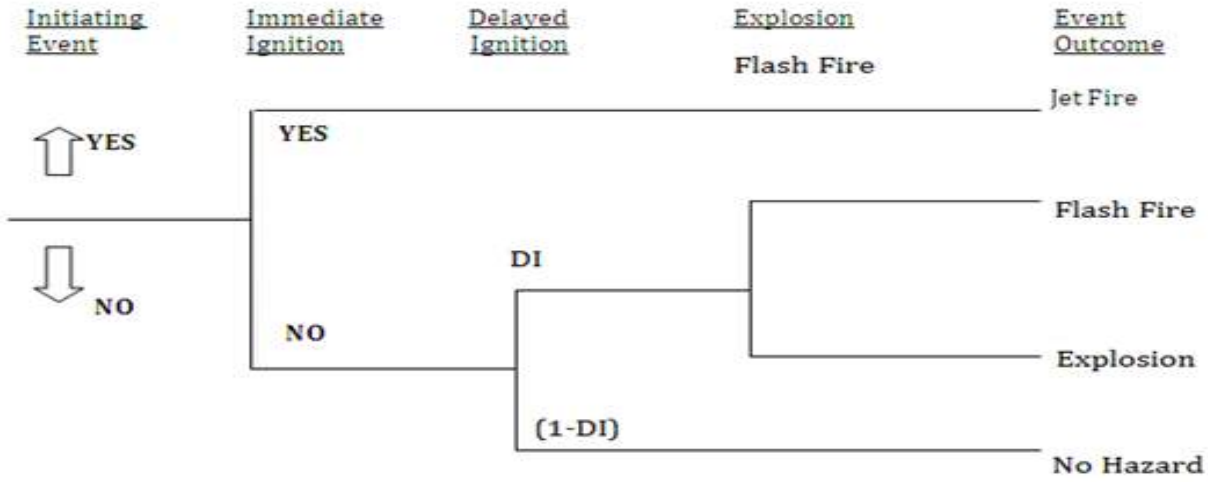


Figure 24:- Event Tree for Continuous Gas Release

6.4.5 Delayed Ignition Probability (DI)

Delayed ignition probability to be calculated based on available ignition source on down-wind direction of released hydrocarbon. Available ignition source may be due to fired heaters, vehicle movement, smoking booth etc.

CHAPTER-7: COMPARISON AGAINST RISK ACCEPTANCE CRITERIA

A risk analysis provides a measure of the risks resulting from a particular facility or activity. It thus finds application as a decision making tool in situations where judgment has to be made about the tolerability of the risk posed by an existing/proposed activity. However, risk analysis produces only numbers, which themselves provide no inherent use. It is the assessment of those numbers that allows conclusions to be drawn and recommendations to be developed. The normal approach adopted is to relate the risk measures obtained to risk acceptance criteria.

Risk criteria, if they are to be workable, recognizes the following:

- There is a level of risk that is so high that it is considered unacceptable or intolerable regardless of the benefits derived from an activity.
- There is also a level of risk that is low enough as to be considered negligible.
- Levels of risk in between are to be considered tolerable subject to their being reduced As Low As is Reasonably Practicable (ALARP). (The meaning of ALARP is explained in the following sub-section.)
- The above is the formulation of the, now well-established, three tier structure of risk criteria and risk control.
- The risk criteria simply attempts to establish whether risk is “tolerable”. Below is a list of words generally in use and their meaning.

ACCEPTABLE RISKS: Since risks in general are unwelcome no risk should be called “acceptable”. It might be better to say that the activity may be acceptable generally, but the risks can only ever be tolerable.

TOLERABLE RISKS: are risks the exposed people are expected to bear without undue concern. A subtle difference is made out here between Acceptable Risks and Tolerable Risks though these terms are sometimes used interchangeably.

NEGLIGIBLE RISKS: are risks so small that there is no cause for concern and there is no reason to reduce them.

7.1 The ALARP Principle

The ALARP (As Low As is Reasonably Practicable) principle seeks to answer the question “What is an acceptable risk?” The definition may be found in the basis for judgment used in

British law that one should be as safe as is reasonably practicable. Reasonably practicable is defined as implying "that a computation must be made in which the quantum of risk is placed on scale and the sacrifice involved in the measures necessary for averting the risk (whether in money, time, or trouble) is placed on the other, and that, if it be shown that there is a gross disproportion between them – risk being insignificant in relation to the sacrifice – the defendants discharge the onus upon them" The ALARP details are represented in the **Figure** below-

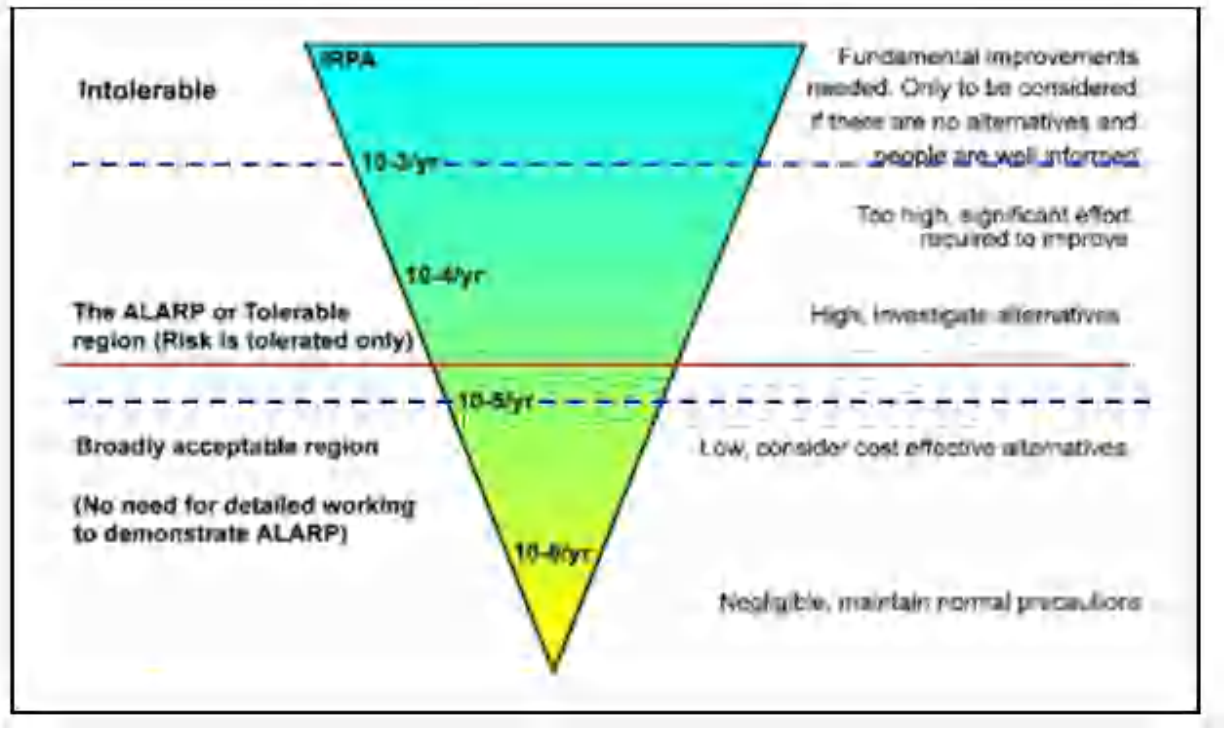


Figure 25:- ALARP Detail

ALARP summary: The Individual and Societal risk per year of Station/terminal is lower of ALARP region and it is broadly acceptable.

CHAPTER-8: RECOMMENDATIONS FOR RISK REDUCTION

8.1 Conclusion and Recommendations

Although the results of this Risk analysis show that the risks to the public are broadly acceptable (or negligible), they will be sensitive to the specific design and/or modeling assumptions used.

The maximum risk to persons working in the Station/terminal is 1 X 10^{-08} per year, 1 X 10^{-09} per year, 1 X 10^{-08} per year and 1 X 10^{-08} per year for Koyali, Viramgam, Sidhpur and Kot station respectively which is below the broadly acceptable level and is in the lower part of ALARP triangle.

It is observed that the ISO-risk contour of 1 X 10^{-08} per year, 1 X 10^{-09} per year, 1 X 10^{-08} per year and 1 X 10^{-08} per year for Koyali, Viramgam, Sidhpur and Kot station respectively are within the Station/terminal. The ISO-Risk Contour of 1 X 10-^{09} per year for Koyali, Sidhpur and Kot station extended to the adjoining facilities which are having generally agriculture land.

The major conclusions and recommendations based on the risk analysis of the identified representative failure scenarios are summarized below:

- The pipeline, Station/terminal is covered in the process safety management system of IOCL.
- It is necessary to provide fire and gas detection system in the Station/Terminal. Operators are well trained about the fire and gas detection system.
- It is recommended to have necessary provision for emergency stop of critical equipments from control room in the event of major leak/flash fire.
- The vehicles entering the Station/terminal should be fitted with spark arrestors and should not be allowed to enter battery area.
- Routine checks to be done to ensure and prevent the presence of ignition sources in the immediate vicinity of the Station/terminal (near boundaries).
- Clearly defined escape routes shall be developed for each individual plots and section of the Stations/terminal taking into account the impairment due to escape of hazardous releases and sign boards be erected in places to guide personnel in case of an emergency.
- Well defined emergency safe locations within station shall be identified for assembling of personnel in one place in case of an emergency.
- Windsocks shall be considered in the plant at prominent place to assist personnel to see the wind direction. This will assist people to escape in upwind or cross wind direction from flammable releases.

- In order to further reduce the probability of failure of catastrophic rupture of pipeline and equipments, critical equipments shall be identified and inspection methodologies to be finalized for continuous monitoring during operation and shutdown maintenance.
- The active protection devices like fire water sprinklers and other protective devices shall be tested at regular intervals.
- There should be an SOP established for clarity of actions to be taken in case of fire/leak emergency.

8.2 General Recommendations

1. Damage distances for the worst case could affect nearby facilities within the terminal/stations and some minimal direct effect on nearby hutments is possible. Due care should be taken if the road is close by and hence close co-ordination with administration is important. As such, the traffic is moderate and no cause of major concern.
2. Ensure that combustible flammable material is not placed near the Critical instrument of the Station/terminal. These could include oil filled cloth, wooden supports, oil buckets etc. these must be put away and the areas kept permanently clean and free from any combustibles. Secondary fires probability would be greatly reduced as a result of these simple but effective measures.
3. Sprinklers need to be provided on all tanks near the Station/terminal. All monitors & hydrants to be shifted at least 15 Mts. away from tank shell.
4. Remote Operated Shutoff Valve (ROSOV) and Hydrocarbon detector should be provided to the pump house of the Station/Terminal as per OISD guidelines.
5. Proper lighting arrangements and CCTV should be provided at terminal/stations.

8.3 Safety Measures

There are following safety measure would be taken for the project, as follows-

i. Hydrocarbon, smoke and fire detectors should be suitably located and linked to fire fighting system to reduce the response time and ensure safe dispersal of vapours before ignition can occur.
ii. Safety devices for critical equipment and processes to be provided.
iii. Emergency shutdown devices (ESD) to be provided at critical field locations.
iv. Automatic fire alarm and detection system to be provided.
v. Automatic process control and monitoring system through PLC/SCADA to be provided.
vi. Fire extinguishing systems like CO_2, DCP, Foam flooding and water sprinkler system to be provided.

vii. Fires resulting from tanker/pump/pipeline leakage are dangerous since the liquid pool becomes unconfined. Training in fire fighting, escape action, operation of emergency switches etc. is vital and should be provided to employees and contract labours working in station/terminal.

viii. Strict adherence inspection, maintenance and operation procedures are to be ensured for preventing any fire/leakage incidents.

ix. Emergency procedures should be well rehearsed and state of readiness to be achieved through frequency mock drill and testing of emergency shutdown systems. Periodic review of an Emergency Response Plan should be done.

x. Hazardous materials should be handled and stored as per MSDS instruction of material.

xi. Tank fires result in little damage at ground levels. Damage at tank height is such as to damage adjacent tanks/areas. Hence tank cooling provisions, particularly upper sections of the tank must be ensured to prevent explosion. Foam flooding system for arresting roof fires must be started automatically/immediately.

8.4 Risk Reduction Recommendation and Mitigation Plan during Natural and Manmade Disaster

8.4.1 Natural Calamities

S. No.	Natural Disaster	Mitigation Plan
1.	Earth Quake	As Koyali, Viramgam, Sidhpur stations belong to seismic zone III & IV. Similarly, Kot station belongs to seismic zone II. Hence, in case of earthquake may lead to fall of structures, buildings and subsequent fire/explosion. All the building and equipments are designed to withstand earthquakes and therefore no major hazard is expected. Some mitigation measures are as follows- • During earthquake, switch off all the electrical connection. • Terminal/station personnel keep constantly touch with local authorities. • Stop all the operations and should not resume till clearance is given by the location in-charge/concerned officer. • Terminal/station personnel must inform to the location in-charge immediately. • Bring all vehicles to halt. • During earthquake, avoid going on top of high

		building/structure. • During earthquake, all personnel should evacuate from buildings/structures and proceed to areas away from walls and windows. • The shift officer should contact operators for a report on employee safety and a condition of terminal/station facilities and equipment. The emergency brigade/team should begin rescue, first aid and damage control activities. • As soon as possible, emergency shutdown procedures should be implemented, Operate ROVs (Remote Operated Valves), isolate valves. stop pumping units. • After earth quake subsides, the personnel should inspect all the facilities for rescue, first aid and damage control activities, damage assessment, clean-up, restoration and recovery.
2.	High Winds	As Koyali, Viramgam, Sidhpur stations belong to high wind speed zone 01 to 02 having wind speed approx. 120-150 km/hr with minimal damage capacity and similarly, Kot station belongs to high wind speed zone 02 having approx. 150-180 km/hr with moderate damage capacity. The following mitigation plan are to be taken: • Terminal/station personnel will be notified by the alarm. • Terminal/station personnel must inform to the location in-charge immediately. • The emergency brigade/team is placed on alert. • Terminal/station personnel are to seek shelter in the administrative building, ground level interior rooms or rest rooms. • All non-essential utilities should be shut-off after the passing of a high wind, personnel should inspect their areas for damage, emergency brigade/team personnel will begin rescue, first aid and damage control activities. Damage assessment, clean up and restoration and other recovery activities should follow. • Avoid going on top of high structures during High winds

8.4.2 Extraneous

S.No.	Man Made Disaster	Mitigation Plan
1.	Riots/Civil Disaster/ Mob Attack	Ensure police, district, regional and corporate notifications have been made as determined by corporate office and/or corporate legal. Do not confront rioters or looters to prevent terminal/station property damage of looting of merchandise. Protect terminal/stations personnel from injury. Remind terminal/stations personnel, about safety protocols.
2.	Terrorism	Protect surveillance records and safeguard areas touched by Terrorist suspects in case of terrorism.
3.	Sabotage	Awareness of potential civil disturbance. Establish policies and safety protocols to address civil disturbances. Security for terminal/station personnel needs to get tighter.
4.	Bomb Threat	Most bomb threats are hoaxes, intended to be disruptive, and if the threat evaluation indicates a response is warranted, must develop an incident action plan (IAP). As part of the pre-emergency planning, determine when you will activate the IAP, whether on receipt of the threat or on discovery of a suspicious package in the target area.
5.	War/ Hit by missiles	Protect surveillance records. Protect terminal/station personnel from injury. Remind terminal/station personnel, about safety protocols.
6.	Abduction	Security of terminal/station needs to get tighter.

8.5 Lessons to Be Learnt

Based on the San Juan fire incident a few lessons learnt are highlighted:

a) Facilities and installations with inherently high hazards should incorporate redundancy in safety systems and ensure their upkeep at all times.

b) Management should ensure that reliable systems are in place to give timely feedback on the current practices and state of readiness in different facilities.

c) Management must ensure that identified actions are being carried out.

d) A high priority on safety from the senior and top management groups will send the right signals down the line to ensure safety and production.

e) High degree of operational competence should be maintained at all times by building on the combined knowledge and experience of all the professional groups. The lessons learnt from all major incidents should be shared and widely disseminated in the entire Industry preferably through an appropriate website.

8.5.1 Safety Management System (SMS)

The failure probabilities largely depend upon how effectively Safety is being managed. This in turn necessitates formal documented Safety Management System (SMS), one that is effective. The features of a Safety Management System are described below.
Analysis of industrial accidents and disasters has clearly shown that these are not simply a consequence of direct technical failure or operator tasks carried out incorrectly. The underlying causes may be deeply rooted in management aspects of the organization. In some cases, the incidents could have been prevented with a formal Safety Management System (SMS). In other situations, a safety management system was in place, but did not prevent the occurrence of the incident. This suggests the need for a wider application of “best practice” safety management system in industry. Moreover, it raises the question of the quality of such systems.

Safety, Health and Environment (SHE) should be a function reporting at the highest management level. There is nothing unusual about this suggestion since such is the practice followed by renowned multi-nationals.

SHE management comprises of a number of elements. For the sake of completeness, as an example, the contents of the SHE program covered in the current practice are given below:

8.6 SMS Elements

- Management leadership, commitment and accountability
- Risk Analysis, Assessment and Management
- Facilities design and construction
- Process and facilities information and documentation

- Personnel safety
- Health
- Personnel
- Training
- Operation and Maintenance procedures
- Work permits
- Inspection and Maintenance
- Reliability and Control of defeat of critical systems & devices
- Pollution prevention
- Regulatory compliance
- Product stewardship
- Management of change
- Third party services
- Incident reporting, analysis and follow-up
- Emergency preparedness
- Community awareness
- Operations integrity assessment and improvement

These elements cannot be used as such. They need to be converted into workable procedures. The twenty one elements listed above for illustration, embrace over 100 distinct requirements with corporate guidelines for each. These system and procedures should detail at least the following:

* Objectives and scope (What is required to be achieved?)
* Tools and procedures (How is it going to be achieved?)
* Resources and responsibilities (Who is responsible? Does he have commensurate resources?)
* Plans and measurement (How is the performance going to be measured?)
* System of monitoring and control (Audit procedures)

8.7 Mock Drill Exercises

Mock drill should be conducted once in six months. Exercises or Drills have two basic functions, namely training and testing. While exercises do provide an effective means of training in response procedures, their primary purpose is to test the adequacy of the emergency management system and to ensure that all response elements are fully capable of managing an emergency situation.

Mock drills are best means of accomplishing the following goals and objectives:

1. To reveal weaknesses in the plans and procedures before emergencies occur.
2. To identify deficiencies in resources (both in manpower and equipment).

3. To improve the level of co-ordination among various response personnel, departments and agencies.
4. To clarify each individual's role and areas of responsibility

CHAPTER-9: HAZOP REVIEW

9.1 Introduction

HAZOP analysis is a systematic technique for identifying hazards and operability problems throughout an entire facility. It is particularly useful to identify unwanted hazards designed into facilities due to lack of information, or introduced into existing facilities due to changes in process conditions or operating procedures.

9.2 General

Mantec Consultants Pvt. Ltd. (MCPL) has been engaged by IOCL, Pipeline Projects Division for carrying out HAZOP/HAZID, and RA study for Pipeline Project. The present report is the HAZOP and HAZID Study report for the Augmentation of Koyali-Sanganer Pipeline based on the design information and suitable conservative assumptions.

9.3 Objectives

The objectives of this study are as follows:

- To identify deviations from the design intent;
- To identify potential hazards and operability problems associated with the deviations;
- To identify and review the adequacy of the existing safeguards, mitigations or preventive measures for the identified hazard event; and
- To recommend ways to mitigate the identified problems or to identify areas that need to be further investigated.

9.4 Scope of Work

The scope of work is to carry out HAZOP and HAZID Study of Augmentation Koyali-Sanganer Pipeline.

The Hazard Identification (HAZID) study is carried out to identify potential hazards from a facility. Hazards, which can harm personnel, environment or property, are identified.

The Hazard and Operability (HAZOP) study is carried out to identify the Hazard and operability problems. In addition, recommendations in the process facilities to reduce the probability and consequences of an incident are to be provided.

9.5 Drawings Used

The drawings/documents utilized for the sessions are listed in Table below-

Table 33: Documents and Drawings Used

S. No.	Document/Drawing Title	Document/Drawing No.
1.	General Layout Plan at Koyali for KSPL Aug Project	9200-10301-302-001-00
2.	General Layout Plan of Viramgam Pump Station	9200-09505-202-051-00
3.	General Layout Plan for Sidhpur Pump Station	9200-10305-302-001-00
4.	General Layout Plan for Kot Pump Station (KSPL Aug PJ)	9200-10307-302-001-00

The HAZOP/ HAZID facilitator did the following:

- Review of design drawings prior to the HAZOP/HAZID session;
- Lead and documented the HAZOP/HAZID sessions; and
- Developed a comprehensive HAZOP/HAZID report and action items list

9.6 HAZOP Process

A block flow diagram of the HAZOP process is given below. The following terms are being used in the HAZOP process.

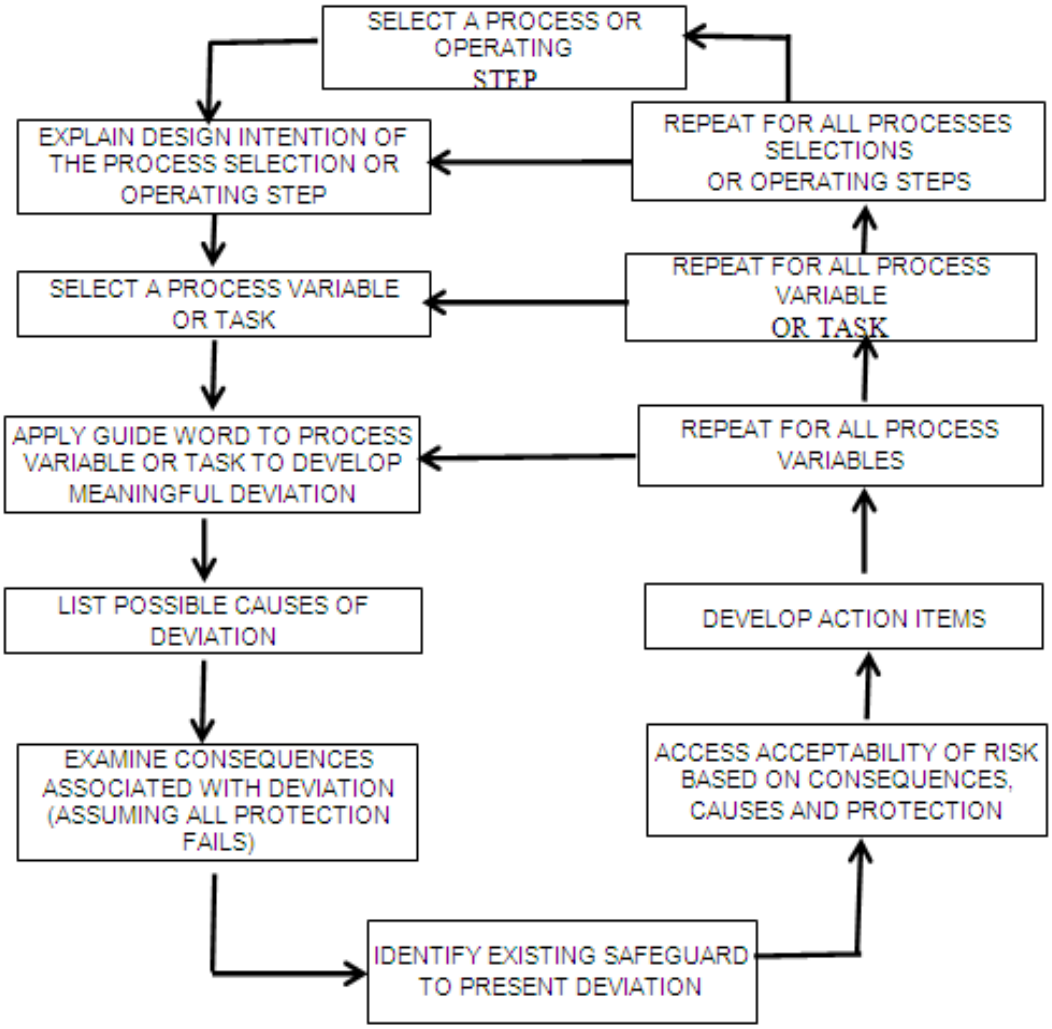


Figure 26:- HAZOP Process

Design intent: the way a process is intentioned to function.

Deviation: a departure from the design intend discovered by systematically applying guide words to process parameters.

Guide word: simple word such as “high” pressure, “high” temperature, “leak” etc. that are used to modify the design intent and to guide the stimulate the brainstorming process for identifying process hazards.

Cause: the reason why a deviation might occur.

Consequence: The result of a deviation.

Safeguard: Engineered system or administrative controls that prevent the cause or mitigate the consequences of deviations.

Hazard category: An assessment of the hazard risk of the operation.

Recommendations: recommendations for design changes, procedural changes, or for further study.

9.7 HAZOP Matrix

Guide word / Process-variable	No	Low	High	Part of	Also	Other than	Reverse
Flow	No flow	Low flow	High flow	Missing ingredients	Impurities	Wrong material	Reverse flow
Level	Empty	Low level	High level	Low interface	High interface	-	-
Pressure	Open to atmosphere	Low pressure	High pressure	-	-	-	Vacuum
Temperature	Freezing	Low temp.	High temp.	-	-	-	Auto refrigeration
Agitation	No agitation	Poor mixing	Excessive mixing	Irregular-mixing	Foaming	-	Phase separation
Reaction	No reaction	Slow reaction	"Runaway reaction"	Partial reaction	Side reaction	Wrong reaction	Decom-position
Other	Utility failure	External leak	External rupture	-	-	Start-up Shutdown Maintenance	-

Figure 27:- HAZOP Matrix

9.8 HAZOP Criticality Analysis

Criticality- Combination of severity of an effect and the probability or expected frequency of occurrence. The objective of a criticality analysis is to quantify the relative importance of each failure effect, so that priorities to reduce the probability or to mitigate the severity can be taken.
Formula for Criticality analysis:
Cr = P X B X S
Cr: criticality number
P: probability of occurrence in a year
B: conditional probability that the severest consequence will occur
S: severity of the severest consequence

Values for P, B and S:

Table 34: Values for HAZOP Criticality Analysis

Categories					
Probability P		**Cond. Probability B**		**Severity S**	
Very rare	1	Very low	1	Low	1
Rare	2	Low	2	Significant	2
Likely	3	Significant	3	High	3
Frequent	4	high	4	Very high	4

9.8.1 Probability (P)

Very rare less than once in 100 years; rare between once in 10 y and once in 100 y; likely between once a year and once in 10 years; frequent more frequent than once a year.

9.8.2 Conditional probability (B)

Very low less than once every 1000 occurrences of the cause; low less than once every 100 occurrences of the cause; significant – less than once every 10 occurrences of the cause; high - more than once every 10 occurrences of the cause.

9.8.3 Severity (S)

Low- no or minor economical loss/small, transient environmental damage; Significant- considerable economic losses/considerable transient environmental damage/slight non-permanent injury; high- major economic loss/considerable release of hazardous material/serious temporary injury; very high- major release of hazardous material/permanent injury or fatality.

For the Augmentation of KSPL

Cr = Rare x Low x Low

Therefore, Combination of severity of an effect and the probability or expected frequency of occurrence for the Project is Low.

CHAPTER-10: BASIS OF HAZOP STUDY

10.1 HAZOP Technique

Safety in the design of Refinery process, petrochemical and offshore plants primarily relies on the application of various codes of practice or design, which are based upon the wide experience and knowledge of professional experts and specialists in the industry. Such application is backed up by the experience of local plant managers, engineers and operators who have direct experience in the relevant plant operation.

All new projects, and in some cases modifications to existing plants, embody some element of change and the degree of change is often considerable. It is important to recognize that experience expressed in codes, etc. is limited by the extent of existing knowledge. It has become increasingly evident in recent years that it is important to supplement these codes with an imaginative anticipation of the hazards that could arise.

One technique developed to study the possibility and consequences of hazardous situations arising is the Hazard and Operability Study (HAZOP) defined as:

"The application of a formal systematic critical examination to the process and engineering intentions of new or modified facilities to assess the hazard potential or mal-operation or mal-function of individual items of equipment and the consequential effects on the facility as a whole".

The technique aims to stimulate the imagination of designers, engineers and operators in a systematic way so that they can identify the potential hazards in a new design or modification works.

HAZOP studies are not an end in them but are part of an overall procedure for the initiation, design, construction, commissioning and operation of the facilities.

The distinguishing feature of HAZOP studies is the "Examination Session" during which a multi-disciplinary team using a structured approach systematically examines all relevant parts of a design.

Essentially the examination procedure takes a full description of the process, systematically questions every part of it to discover how deviations from the design intent can occur and decides whether these deviations can give rise to hazards or operational/maintenance problems.

The questioning is focused in turn on every part of the design. Each part is subjected to a number of questions formulated around a number of guidewords/deviations. In effect, the guidewords/deviations are used to ensure that the questions will explore ways in which the process could deviate from the design intent.

Some of the causes of a deviation may be unrealistic and derived consequences insignificant, and would therefore not be considered further. However, there may be a deviation with both conceivable causes and potentially hazardous consequences. Essentially the HAZOP study identifies problem areas and does not seek engineering solutions although recommendations of

an obvious nature can be made. In some cases it will be necessary to obtain further information and/or carry out detailed studies/analysis.

10.2 Methodology

This study was conducted through a node by node review, i.e. the system was divided into discrete nodes and each node was numbered accordingly.

The method involved several repetitive steps:

i) Identify a node of the process on the P&IDs.
ii) Define the design intent and normal operating conditions of the node.
iii) Identify a deviation from the intent or operating condition by applying guidewords based on the BS - IEC 61882 lists of guidewords.
iv) Identify possible causes and consequences of the deviation. A deviation can be considered "meaningful" if it has a credible cause and can result in harmful consequences.
v) Identify safeguards, if any.
vi) Identify recommendations and action parties if no safeguard is provided or safeguards are insufficient.

In practice the guidewords/deviations are set down in a standard list of questions relevant to the systems under review. The following guidewords/deviations were used in this study:
The basic methodology for HAZOP Study is shown in **Figure** below-

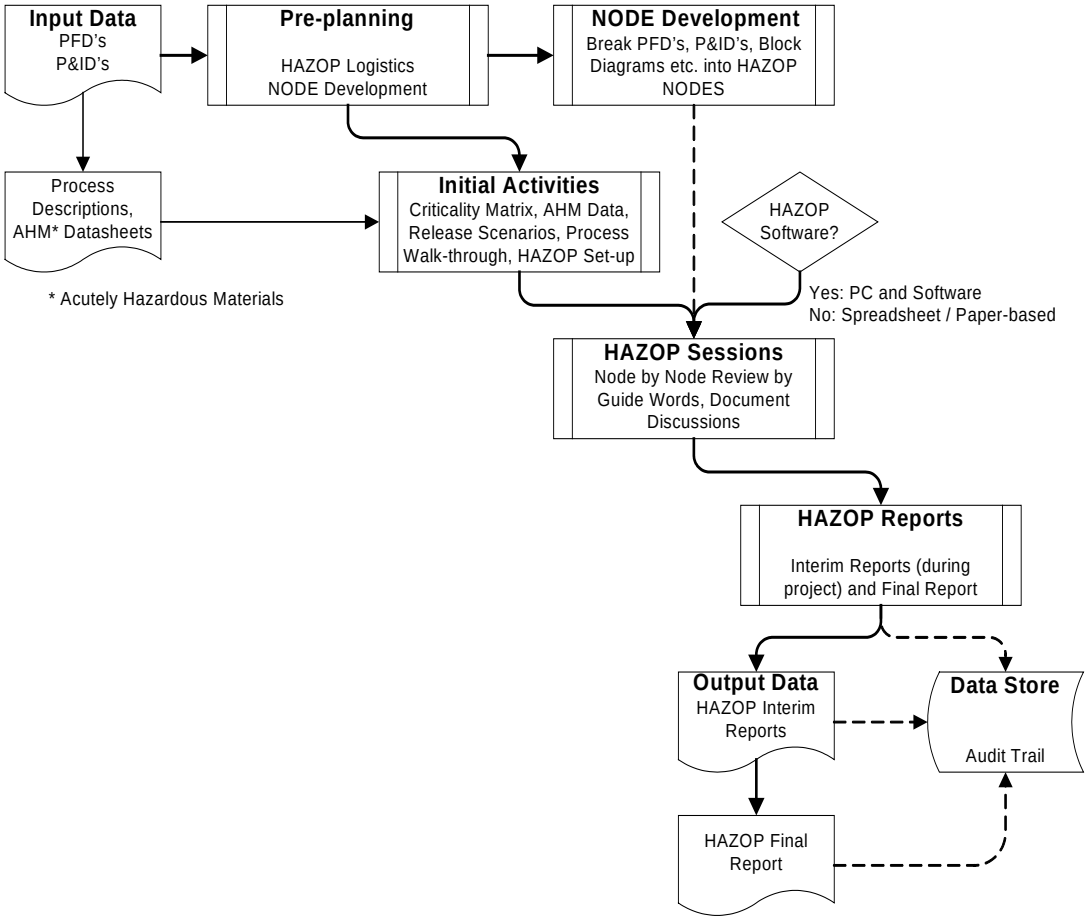


Figure 28:- Methodology for HAZOP Study

Table 35: Guidewords/Deviations used for HAZOP

Guide-word Code	No.
More Flow	01
Less / No Flow	02
Reverse Flow	03
Other Than Flow	04
High Pressure	05
Low Pressure	06
High Temperature	07
Low Temperature	08
High Level	09
Low Level	10
Composition	11
Start-up / Shut-down	12
Maintenance	13
Corrosion / Erosion	14
Drawing Error	15
Static Charge	16

10.3 HAZOP Pre Concessions

Throughout the HAZOP session, the following rules were adopted:

i) In principle, only single failure results in hazard – no double jeopardy.
ii) All equipment are well designed, manufactured and properly inspected.
iii) Plant is well maintained and operated in accordance with acceptable standards.
iv) Failures of instrument gauges were not considered.
v) Mechanical protection devices (PSVs (Pressure Safety Valves), rupture discs) are expected to work.
vi) No design work/quantitative analysis will be performed during HAZOP meeting.
vii) Impact on environment (e.g. dispersion) will not be analyzed.
viii) If there is more than one train or pass, study of one is ok.
ix) Single check valve is adequate unless reverse flow may cause pressure to exceed test pressure.
x) Equipment is deemed suitable for the specified design conditions.

xi) The following items will not be considered:

- Spares for maintenance.
- Simultaneous occurrence of two unrelated incidents
- Simultaneous failure of more than one independent protection devices
- Operator's negligence (except common human error)
- Natural calamity (e.g. flood, earthquake)
- Objects falling from sky
- Sabotage

xii) The following is deemed as protection/safeguard

- Interlock/shutdown system/trip
- Alarm system for operator action
- Mechanical protection device
- Sample monitoring system
- Operating instruction and operating manuals

CHAPTER-11: RESULTS AND DISCUSSION

No major fault found during hence no recommendation required.

11.1 List of Nodes

The facility under consideration was analysed/ studied as Two (2) Nodes, based on the process and the operating conditions.

11.2 Follow Up Action List

No specific recommendations were proposed during the HAZOP sessions.

CHAPTER-12: REFERENCE

1. Hazard and Operability Studies (HAZOP Studies) Application Guide. British Standard BS IEC 61882:2001.
2. HAZOP Guide to Best Practice by EPSC
3. Layout as obtained from IOCL Pipeline

CHAPTER-13: HAZID REGISTER

13.1 General

The HAZID Study is a high level qualitative risk assessment, which is commonly utilized to identify potential hazards from a facility. Hazards, which can harm personnel, environment or property, are identified. The HAZID assessed the consequences taking into account the mitigation provided in the design, and then defined any actions necessary to further mitigate risk to an acceptable level.

13.2 HAZID Methodology

The HAZID was performed by a multidisciplinary team from IOCL Pipeline Division & MCPL, to ensure that the HAZID review was comprehensive. The agreed action items were recorded on the HAZID worksheets.

The drawings and support documents were referred to as appropriate. The study progressed through the following steps:

- The design intent and normal operating conditions of the area;
- Identify possible causes and consequences of the hazard. A hazard can be considered "meaningful" if it has a credible cause and can result in harmful consequences;
- Identify any existing safeguards, mitigations and control measures included in the design;
- Carry out a ranking of the hazards based on its safety or environmental impacts; and
- Identify recommendations and action parties if further mitigation is required.

In keeping with the purpose of the study, MCPL developed a number of guidewords that were used in the HAZID workshop to initiate discussion within the HAZID team. The guidewords used in this study are summarised in **Table** below-

Table 36: Guidewords used for the HAZID Study

S. No	Guideword
1.	Unignited Hydrocarbon Release
2.	Ignited Hydrocarbon Release–Fire
3.	Toxic Release
4.	High/Low Pressure
5.	High/Low Temperature
6.	Dropped Object
7.	Maintenance
8.	Confined Spaces
9.	Access/Egress/Escape/Evacuation
10.	Extreme Weather
11.	Radioactivity
12.	Explosives
13.	Sabotage/Piracy/Acts of Terrorism/Theft
14.	HAC (Hazardous Area Classification)
15.	Electrostatic
16.	Electrical Fire

13.3 Risk Ranking

Based on the estimated frequencies and consequences, the identified hazards were then assessed and ranked accordingly to their severity using the risk matrix presented in **Table** below-

The HAZID risk ranking is performed for consequence to people, asset, environment and reputation.

13.4 HAZID Worksheets

In the "Cause" column, all the potential causes which contribute to a particular hazard were recorded. If any safeguards/mitigation measures are provided to prevent or minimize risk or further escalation, then they were documented in the "Preventive and Mitigation Measures" column. In the absence of adequate safeguards for the hazards identified, relevant recommendations from the team were noted in the "Recommendations" column.

Table 37: Quantitative Risk Analysis Matrix

CONSEQUENCE OF HAZARD				ANNUAL FREQUENCY				
				A	B	C	D	E
Severity	People (P)	Assets (A)	Environment (E)	<0.00001	0.0001–0.00001	0.001–0.0001	0.01–0.001	>0.01
0	No injury	No damage	No effect	L	L	L	L	L
1	Slight injury	Slight damage	Slight effect	L	L	L	L	M
2	Minor injury	Minor damage	Minor effect	L	L	L	M	M
3	Major injury	Localised damage	Localised effect	L	L	M	M	H
4	Single Fatality	Major damage	Major effect	L	M	M	H	H
5	Multiple Fatalities	Extensive damage	Extensive effect	M	M	H	H	H

13.5 Results of the HAZID Study

Each accident event has been assessed to determine its likely frequency and its consequences in terms of death/injury to personnel and damage to environment, assets and reputations. The assessment has been conducted on a qualitative basis and is inevitably subjective. It gives an indication of where to focus when carrying out more detailed analysis. A risk matrix has been used to rank the level of risk from each event and identify it as 'low', 'medium' or 'high'.

A total of Eighteen (18) hazards were identified in the HAZID session. Out of the Eighteen (18) hazards, Ten (10) were classified as low risk hazards and Eight (8) as medium risk hazards. However, no high risk hazards have been identified.

13.5.1 Corrective Actions

No specific recommendation was made for the Augmentation of Koyali-Sanganer Pipeline Project.

ANNEXURE-A

Risk Analysis Graph

Kot

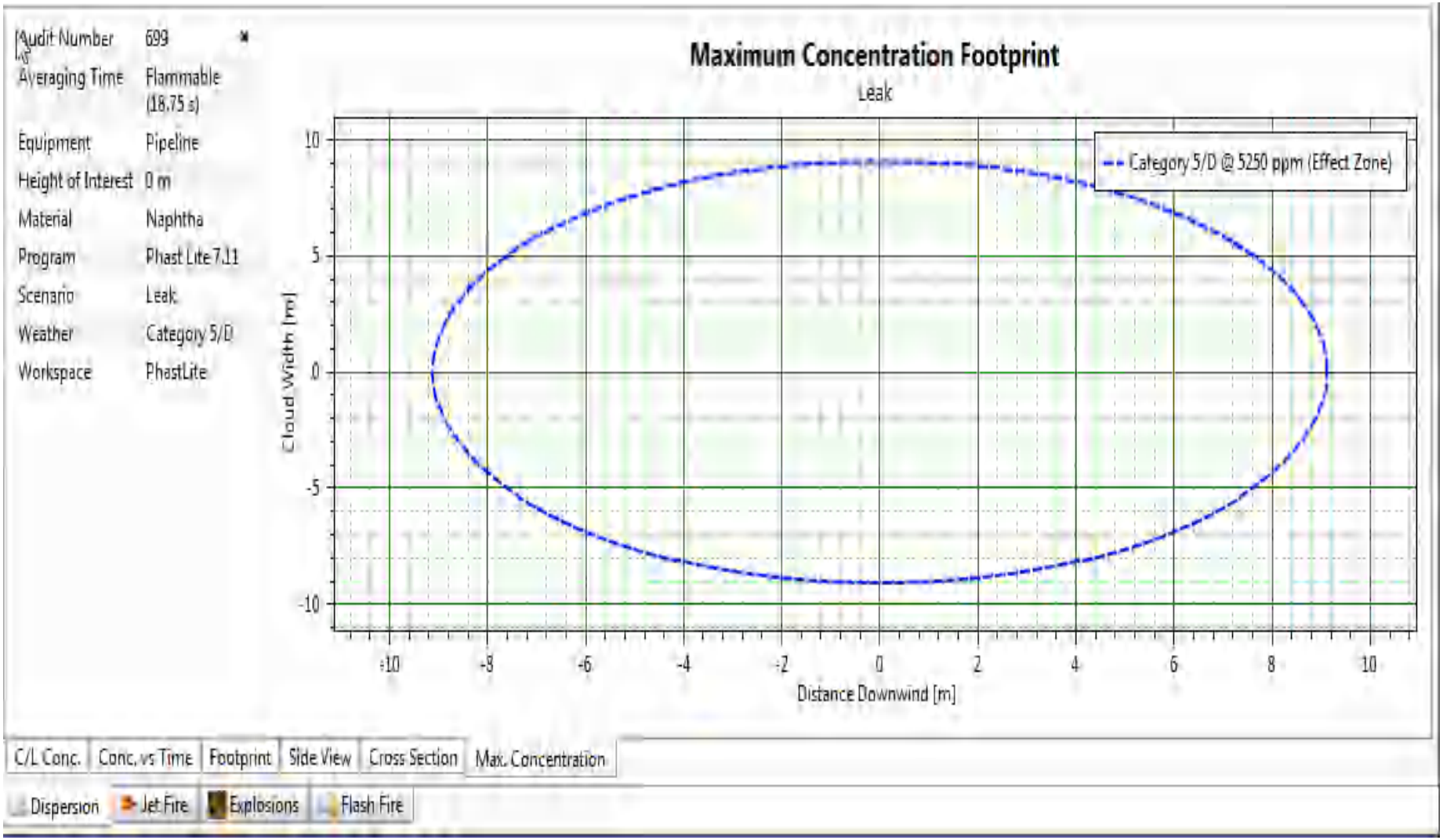


Figure 29:- Graph showing leak of Maximum Concentration Footprint from pipeline of Kot station.

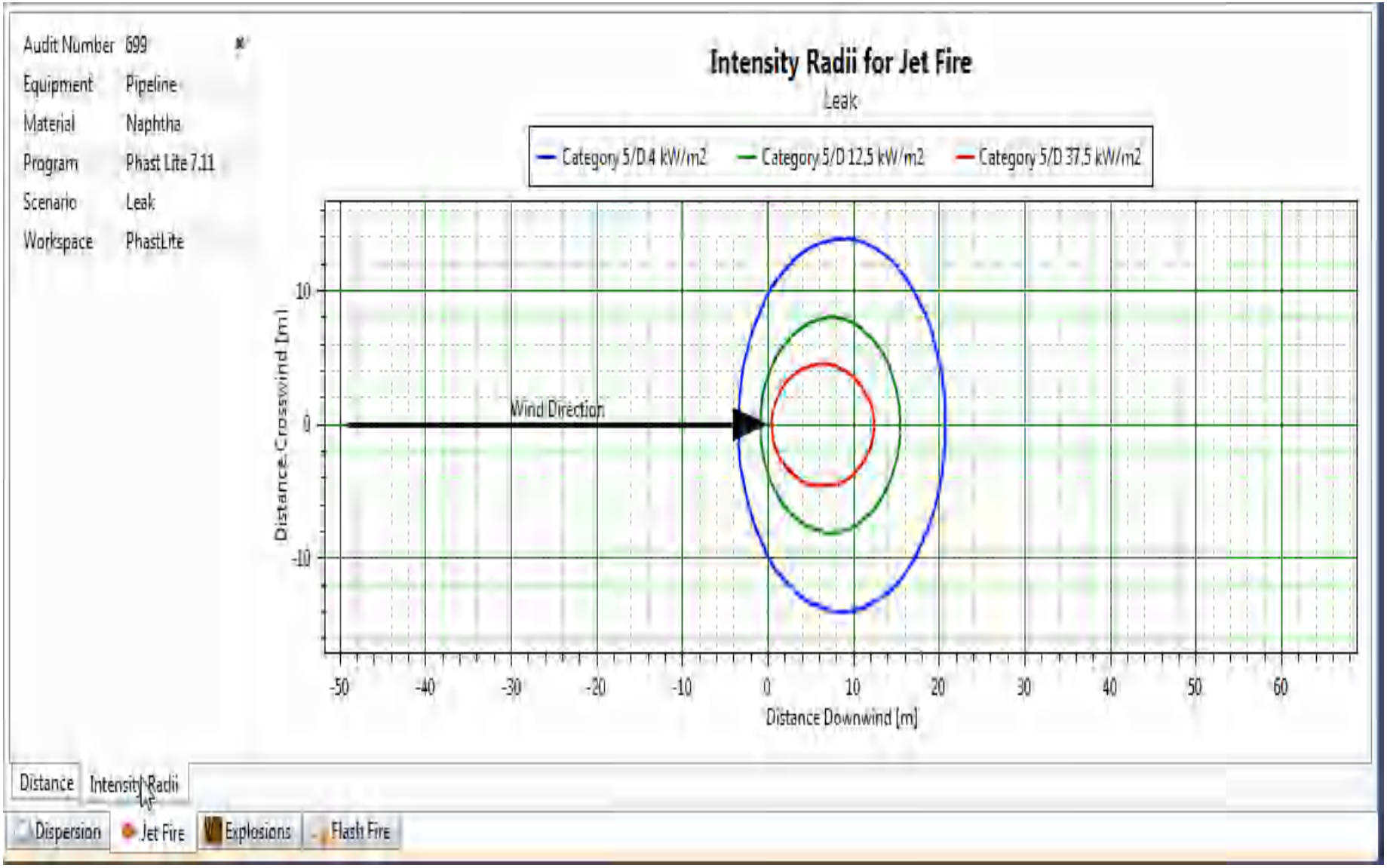


Figure 30:- Graph showing leak of Intensity Radii for Jet Fire from Pipeline of Kot station.

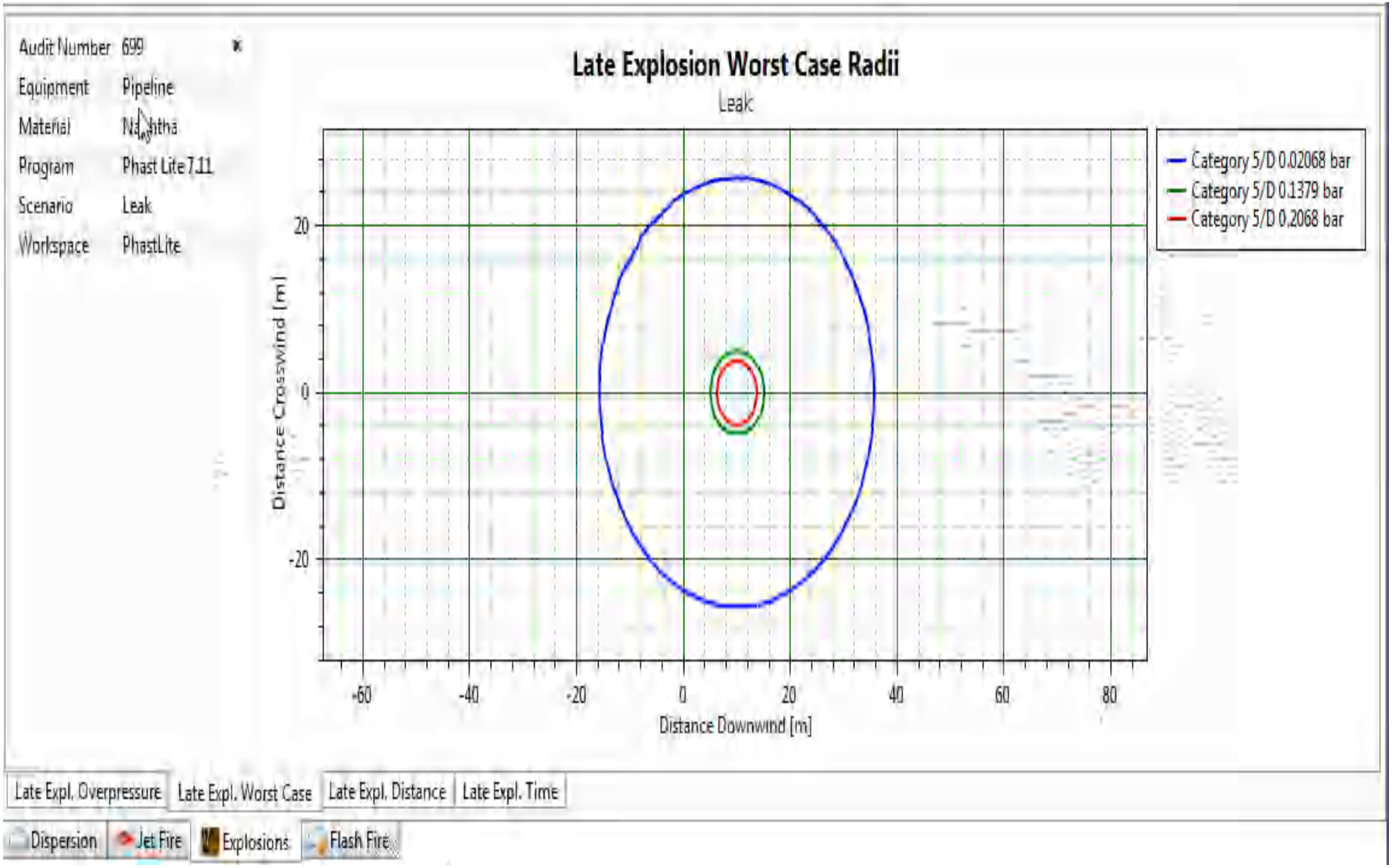


Figure 31:- Graph showing leak of Late Explosion Worst Case Radii from Pipeline of Kot station

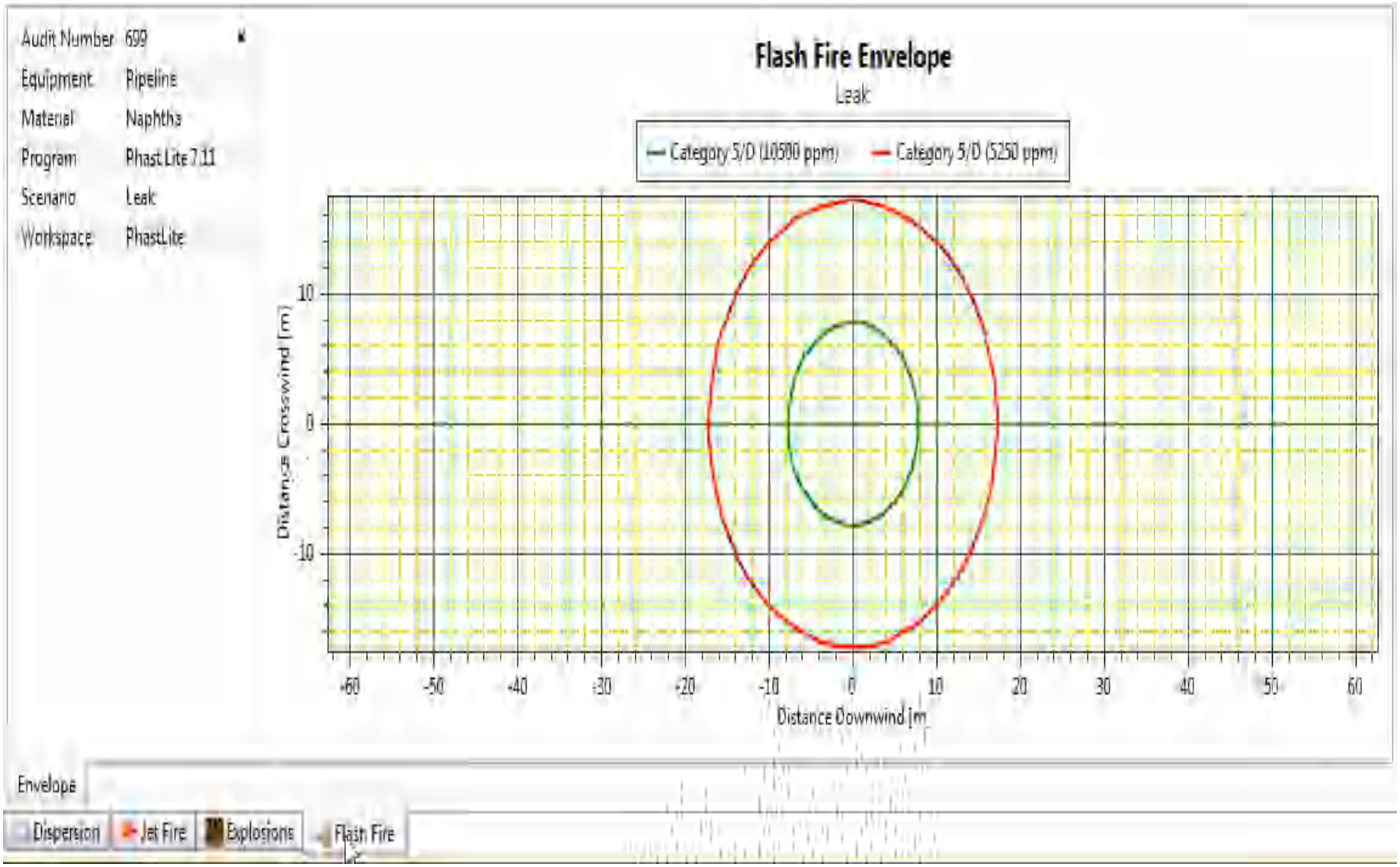


Figure 32:- Graph showing leak of Flash Fire Envelope from pipeline of Kot station.

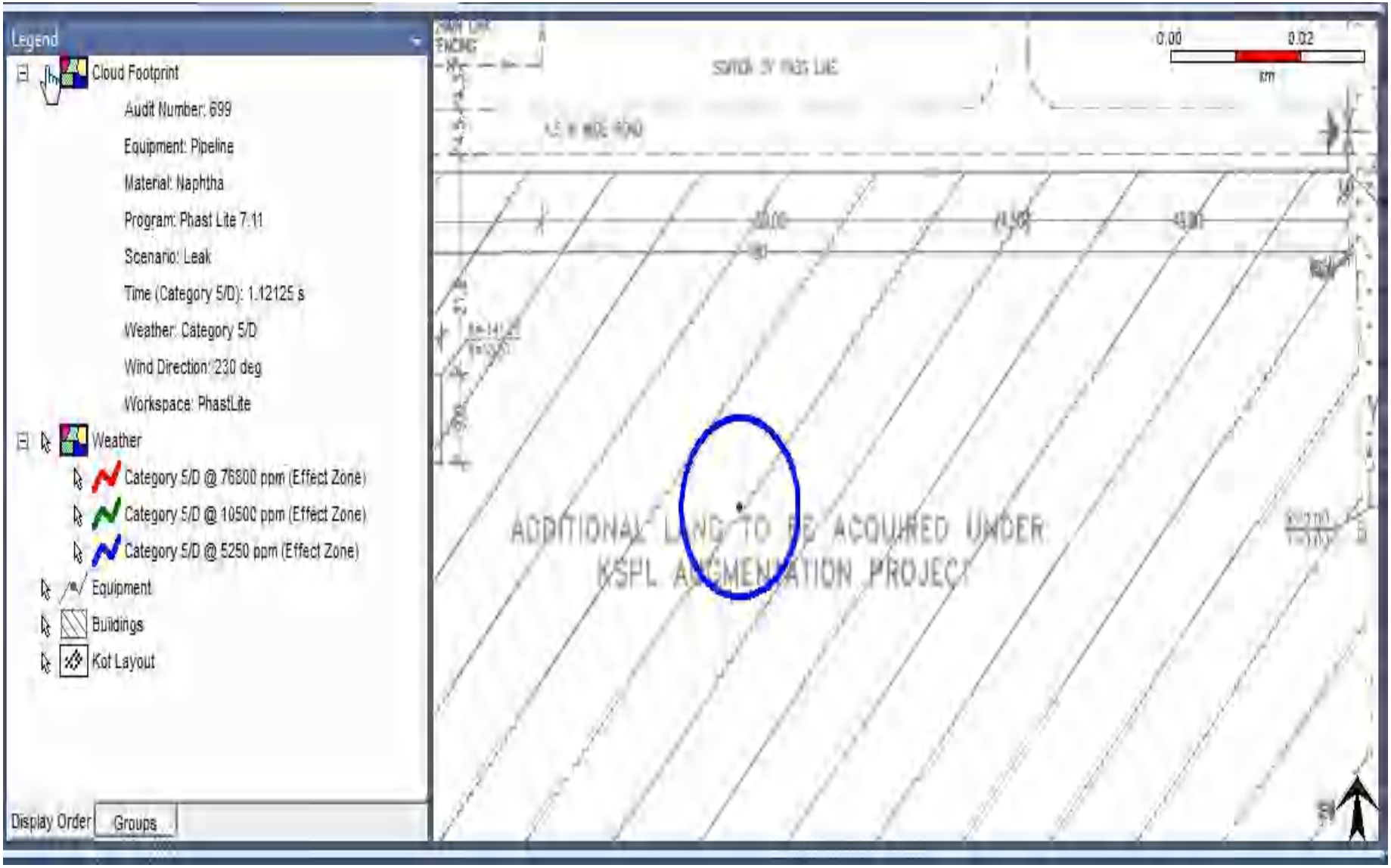


Figure 33:- Cloud footprint of Kot station (Leak from pipeline on Plant layout).

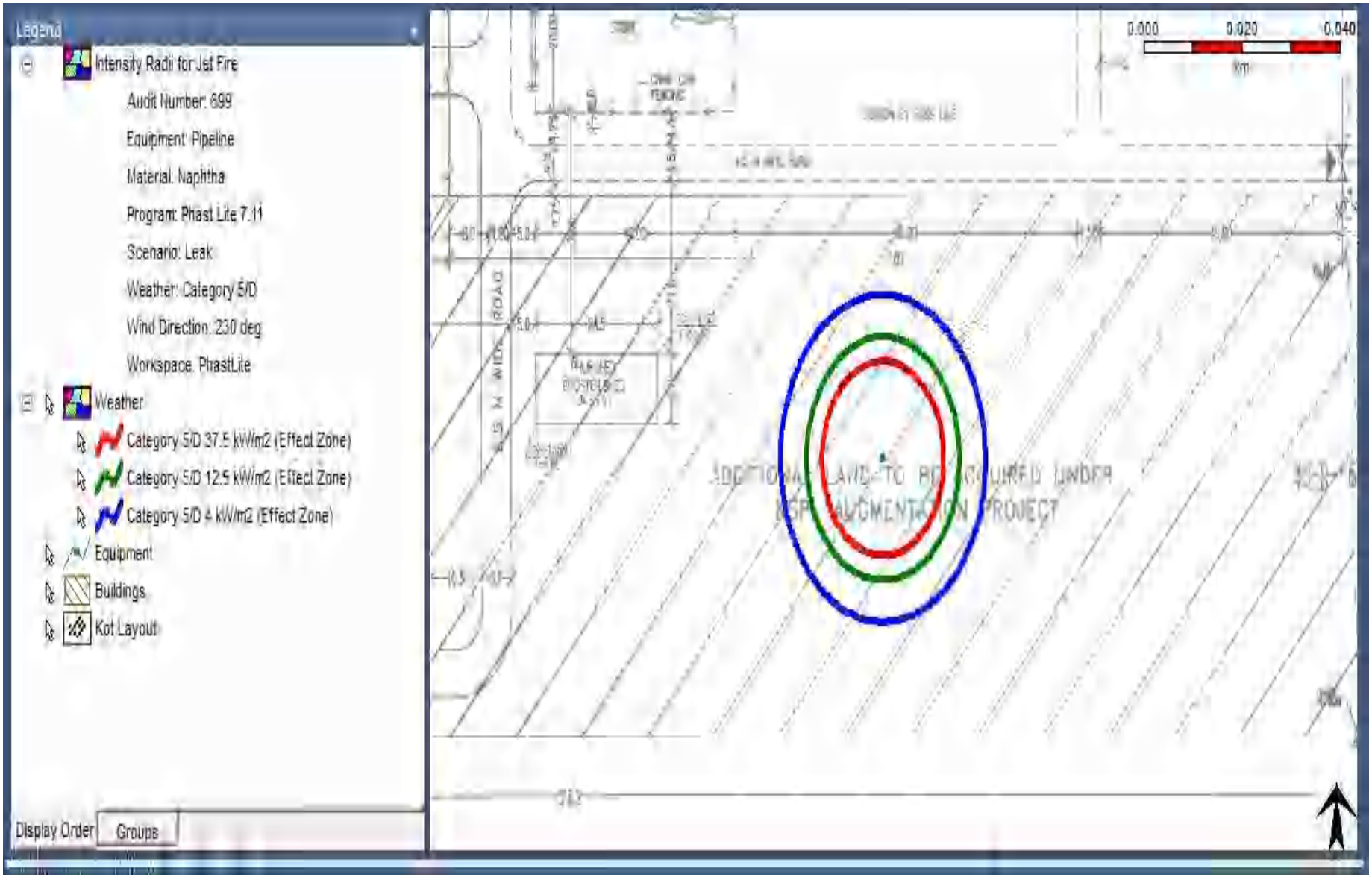


Figure 34:-Intensity radii for Jet fire of Kot station (Leak from pipeline on plant layout)

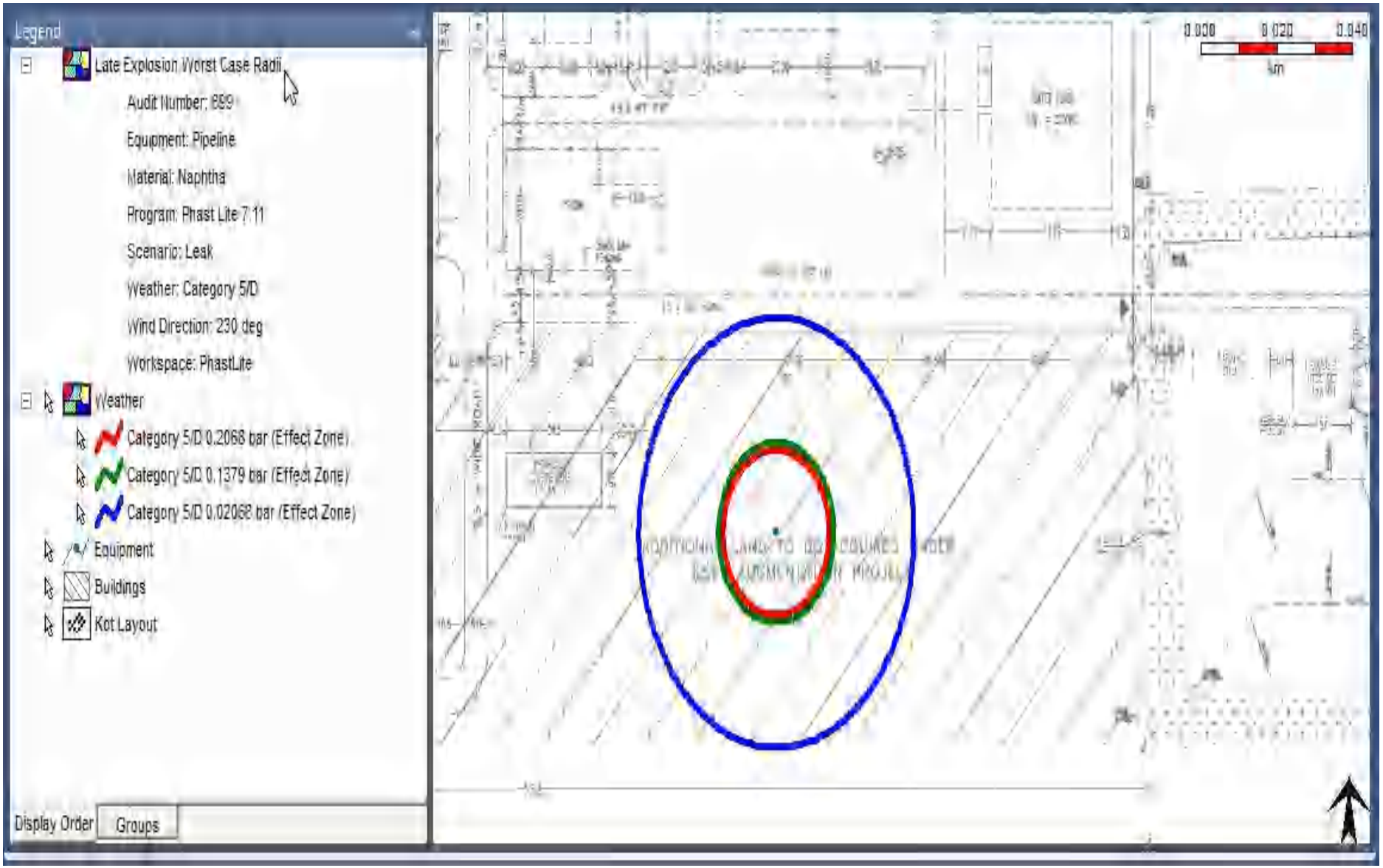


Figure 35:- Late Explosion Worst Case Radii of Kot station (Leak from pipeline on plant layout)

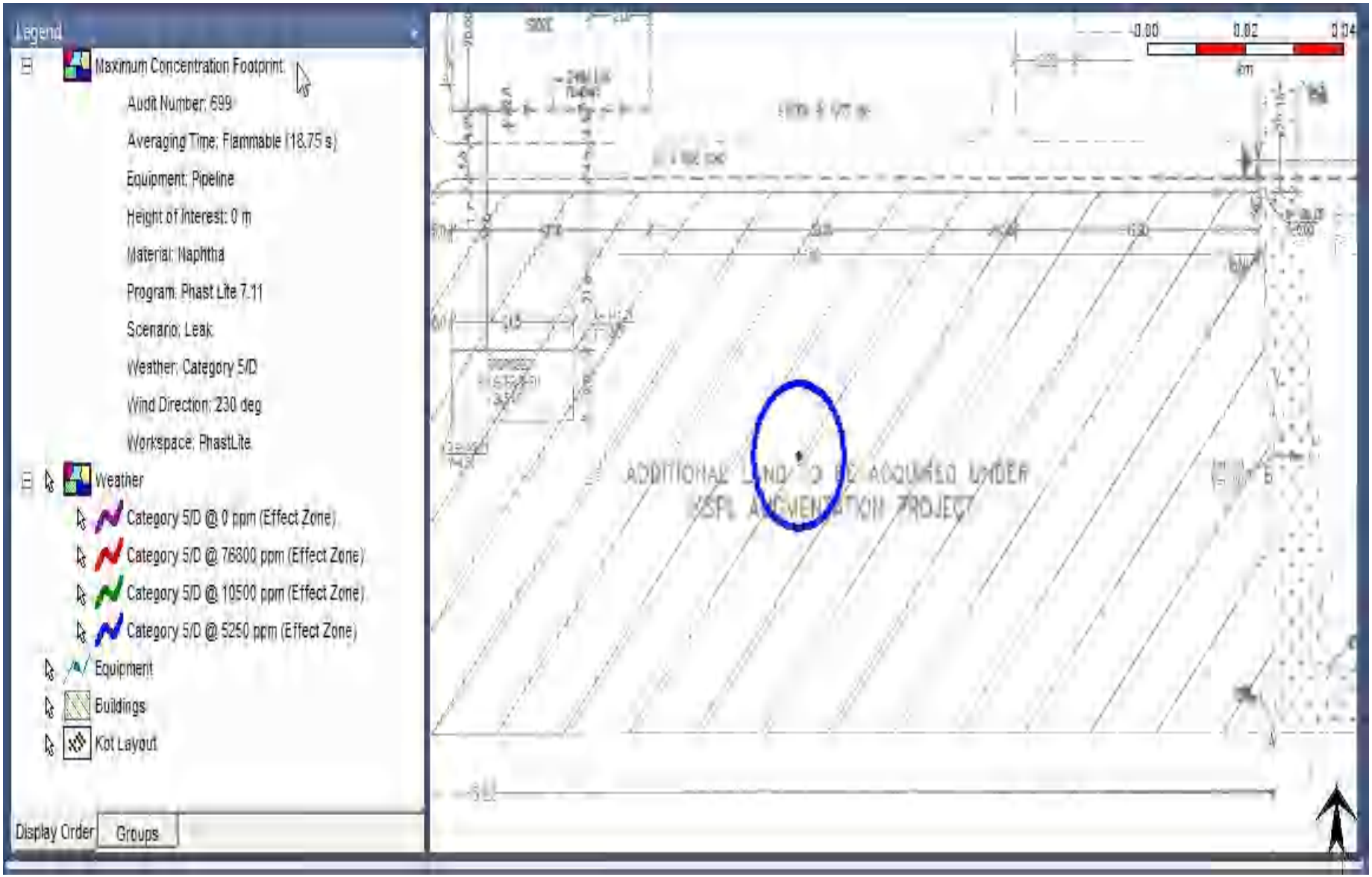


Figure 36:- Maximum Concentration Footprint of Kot station (Leak from pipeline on plant Layout)

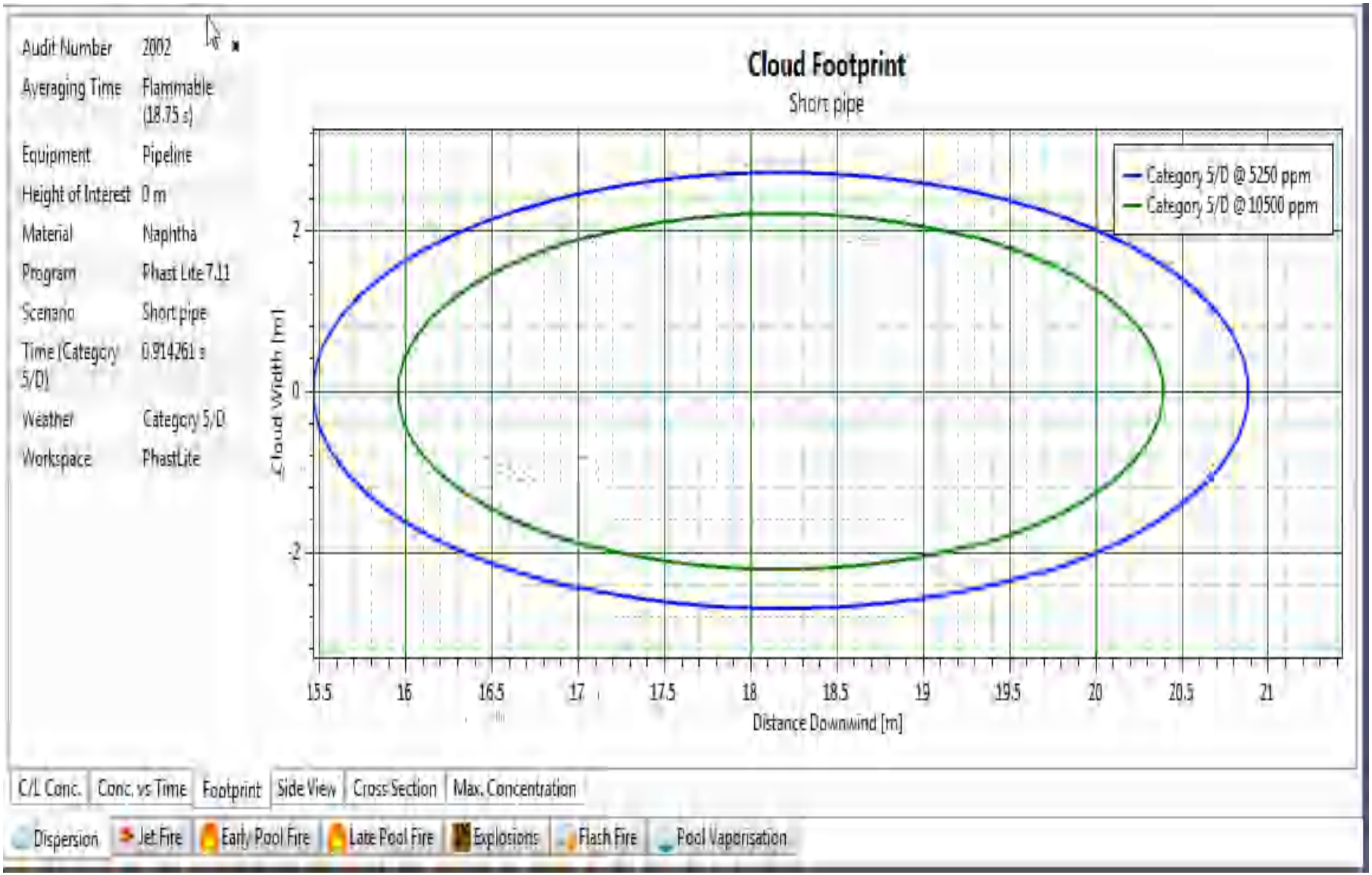


Figure 37:- Graph showing rupture of cloud footprint from pipeline of Kot station.

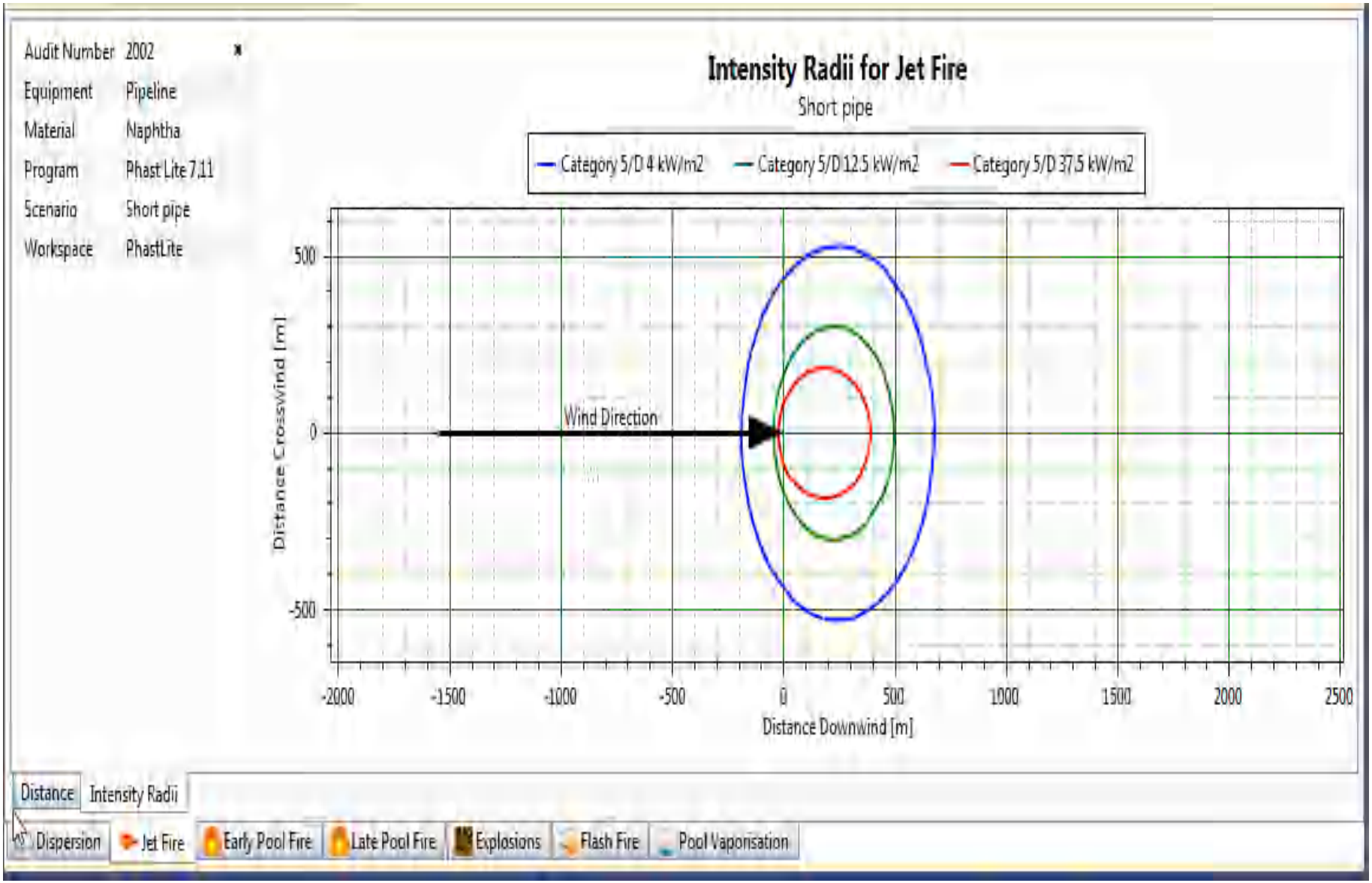


Figure 38:- Graph showing rupture of Intensity Radii for Jet Fire from pipeline of Kot station.

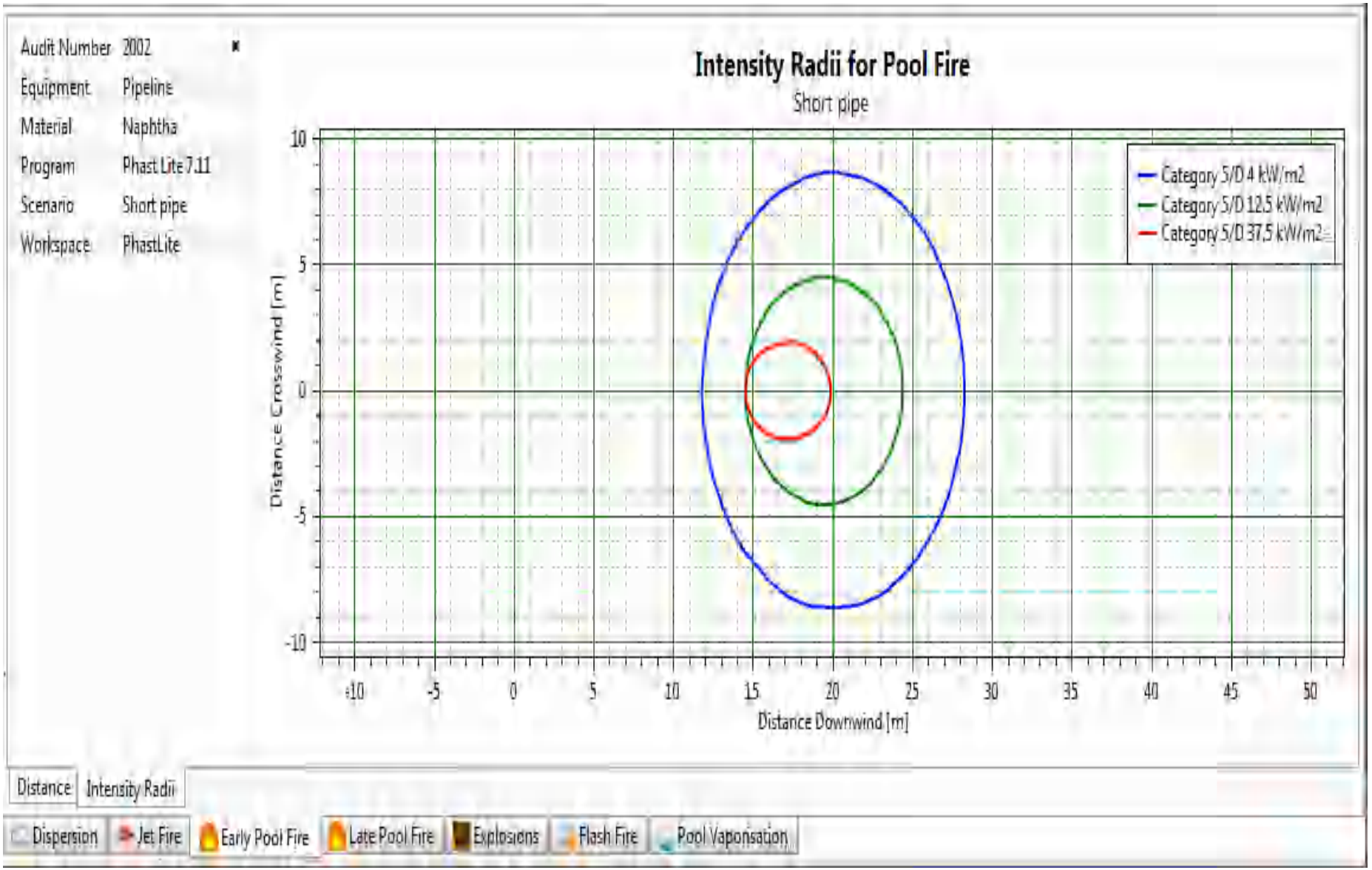


Figure 39:- Graph showing rupture of Intensity radii of Pool fire from pipeline of Kot station.

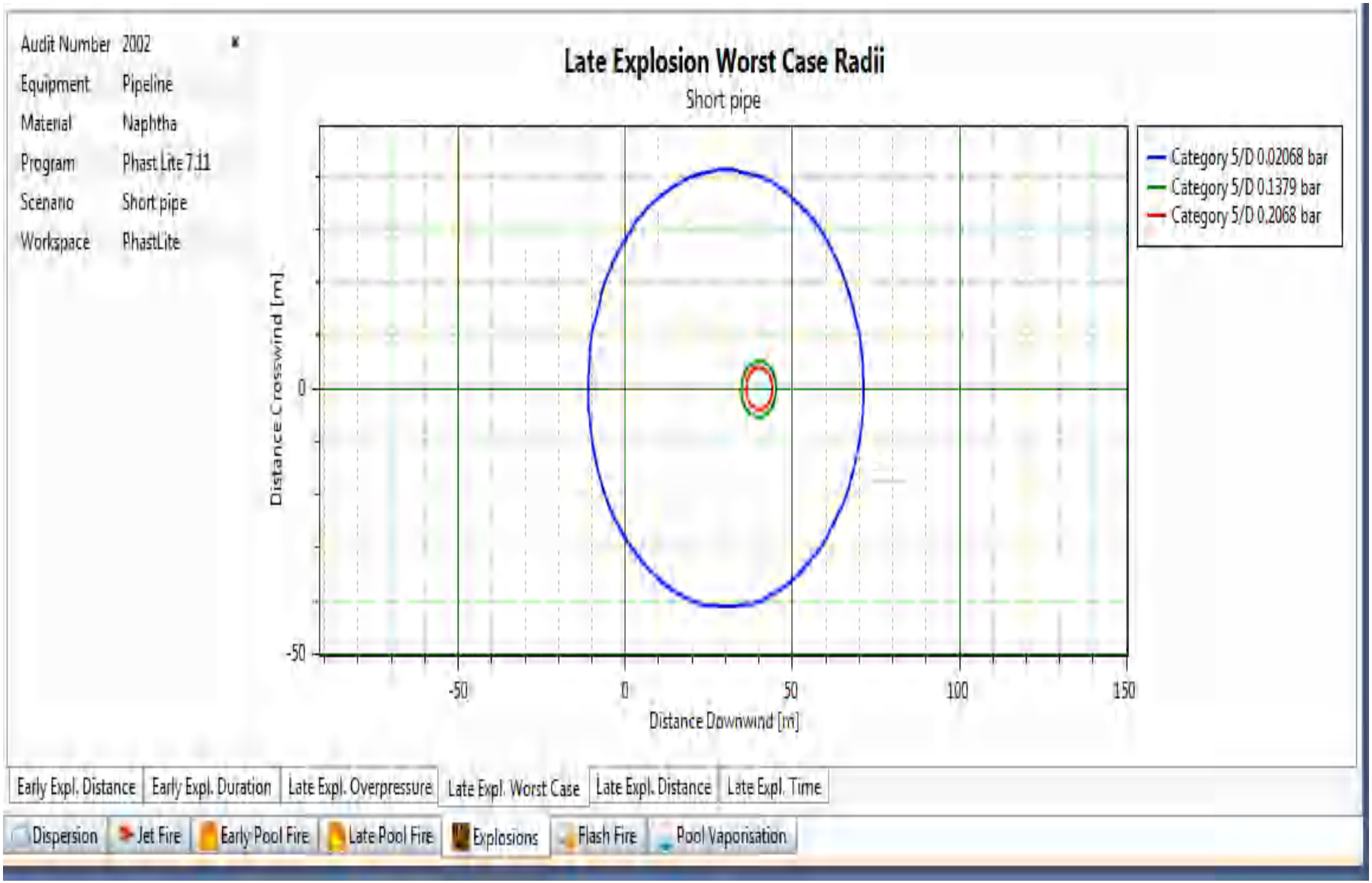


Figure 40:- Graph showing rupture of Late Explosion Worst Case Radii from pipeline of Kot station.

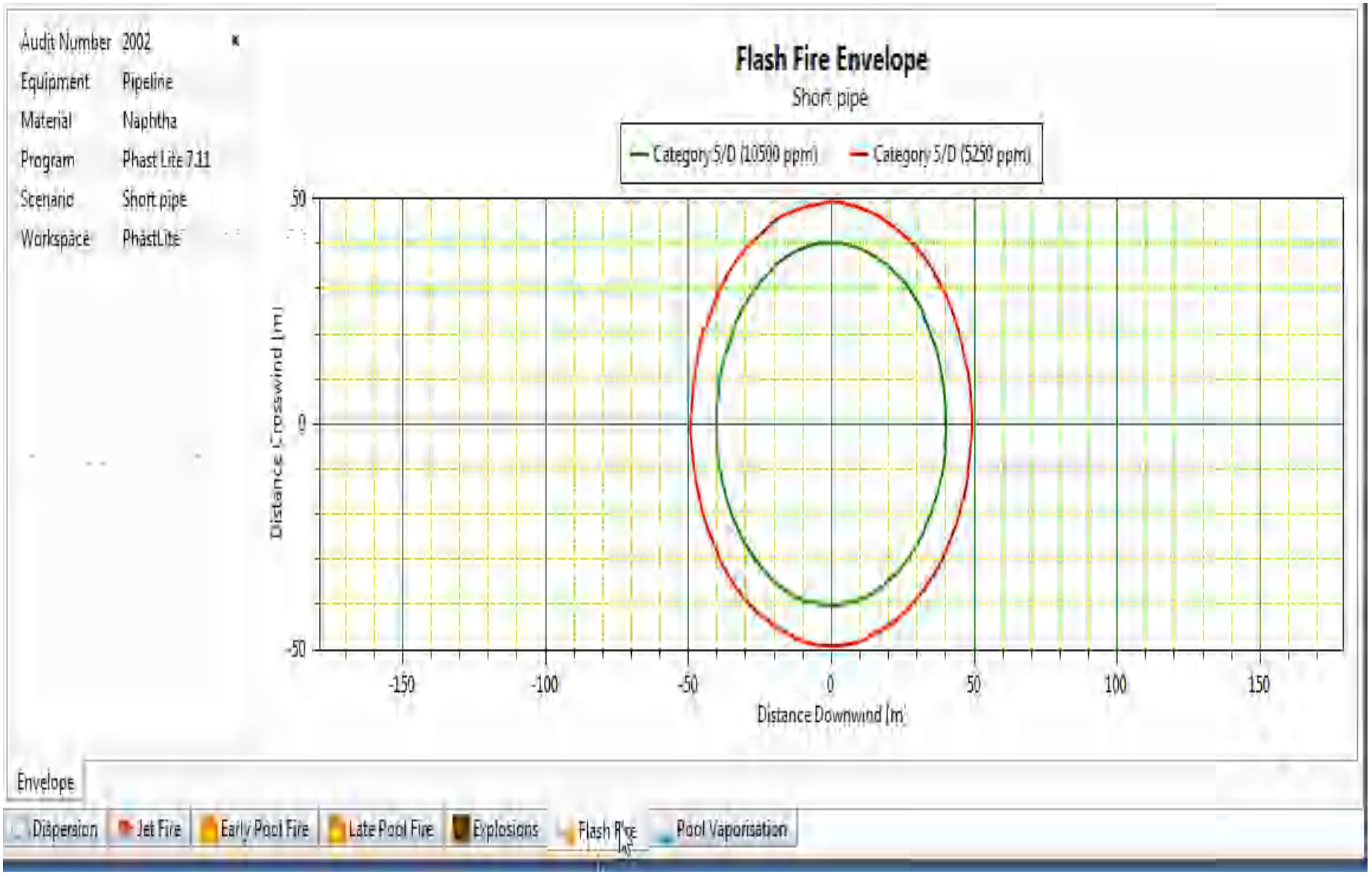


Figure 41:- Graph showing rupture of Flash Fire Envelope from pipeline of Kot station.

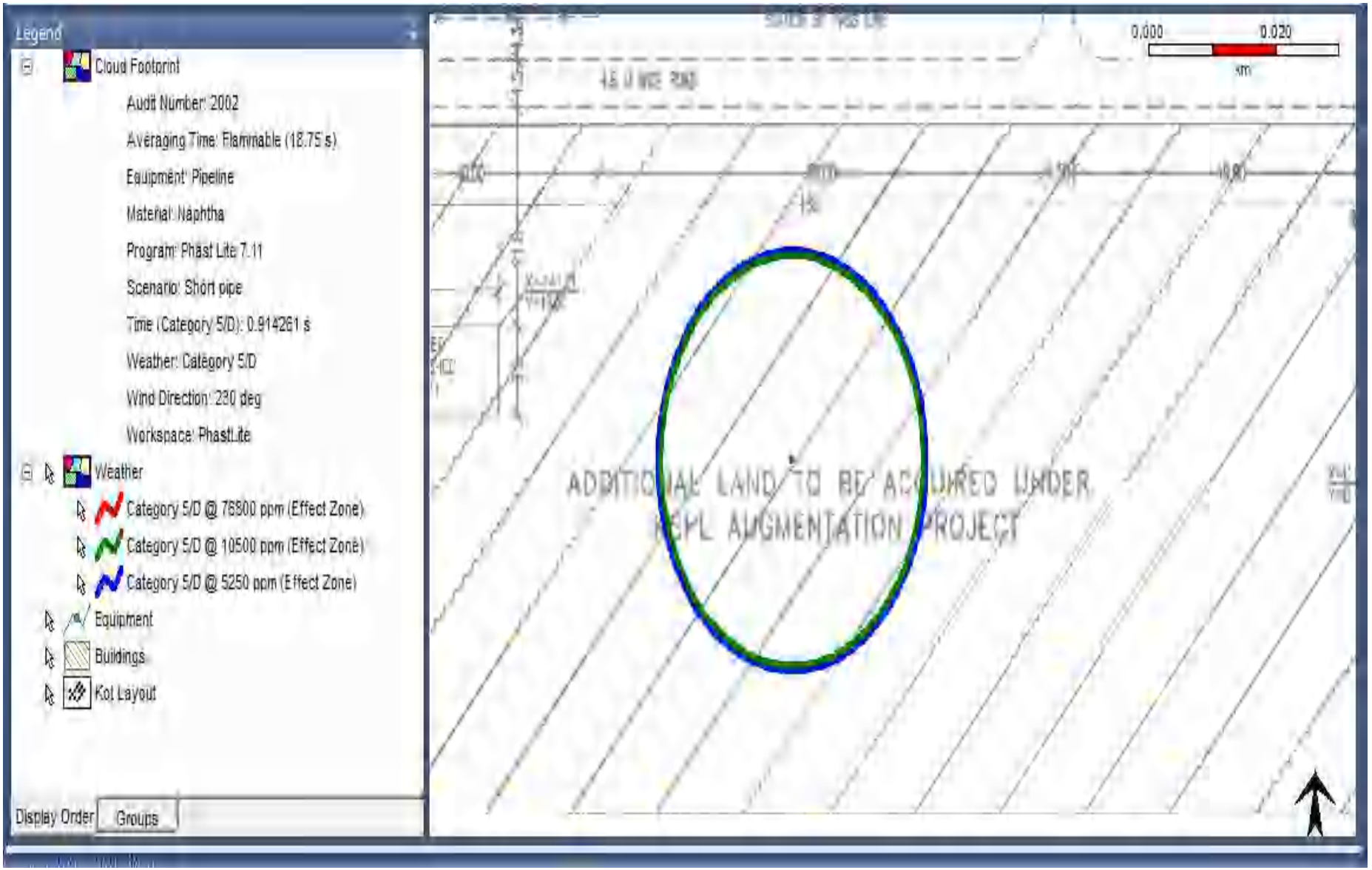


Figure 42:- Cloud Footprint of Kot station (Rupture for pipeline of plant layout)

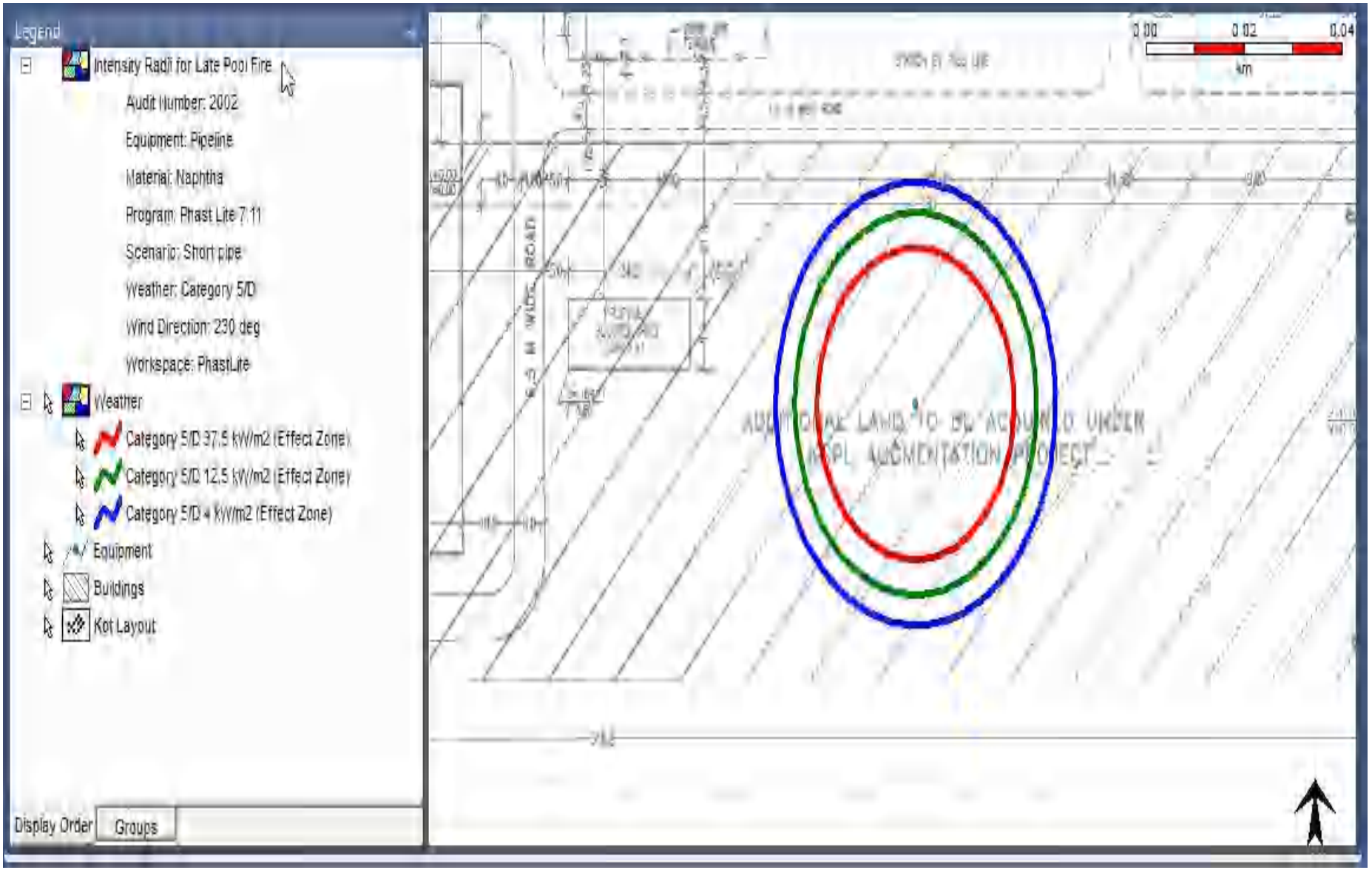


Figure 43:- Intensity Radii for Late Pool Fire of Kot station (Rupture for pipeline of plant layout)

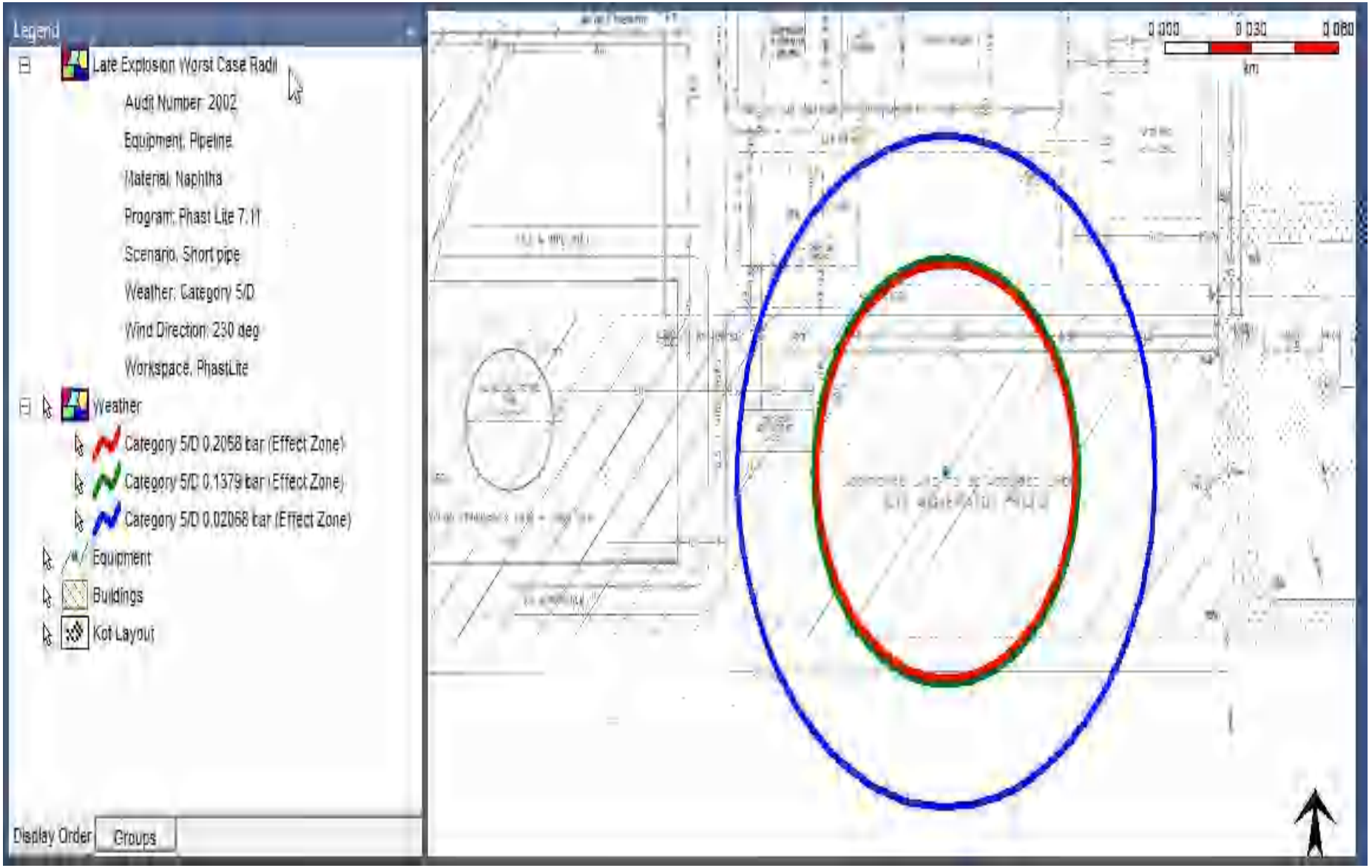


Figure 44:- Late explosion worst case Radii of Kot station (Rupture for pipeline of plant layout)

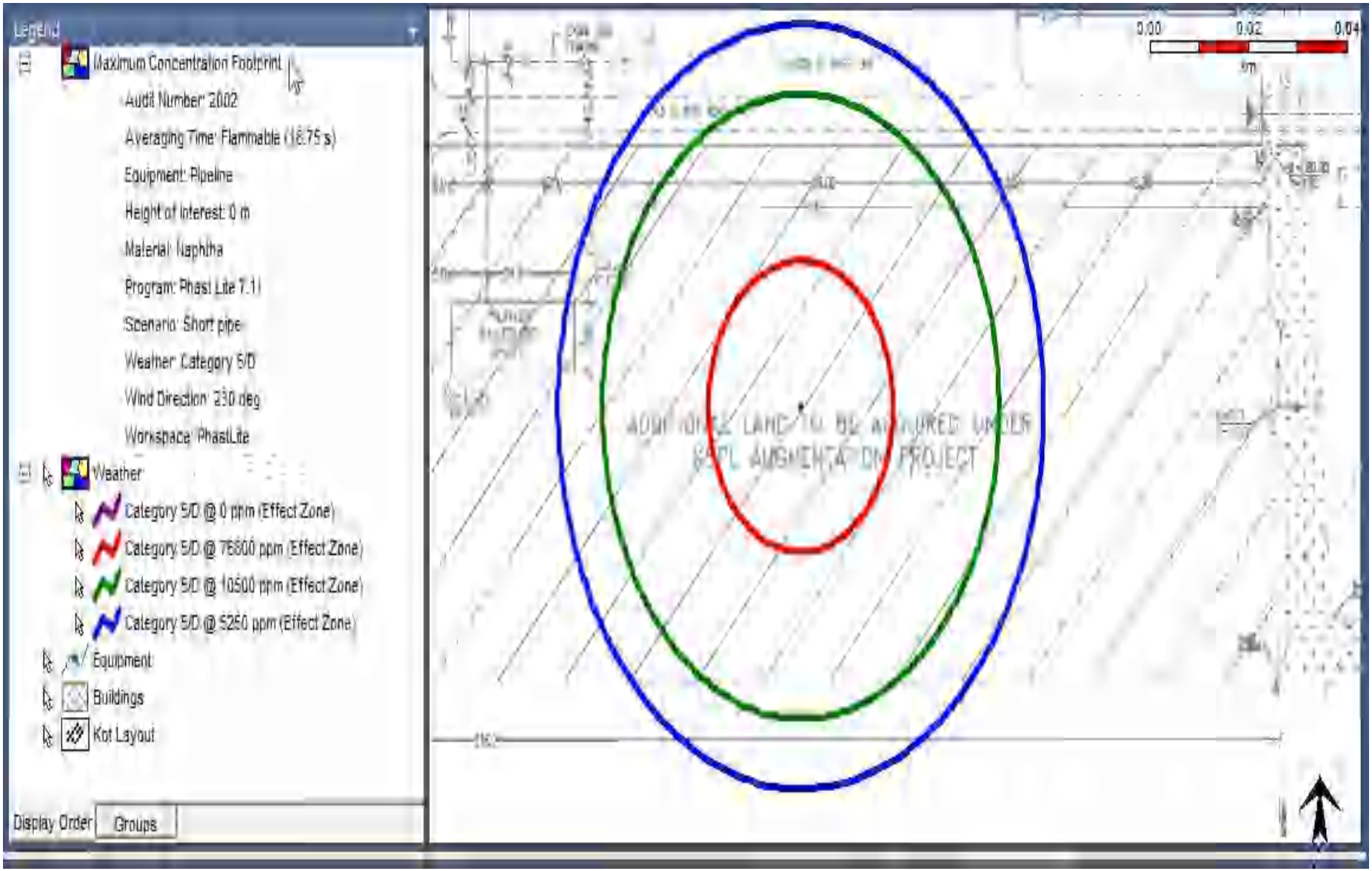


Figure 45:- Maximum Concentration footprint of Kot station (Rupture of pipeline)

Sidhpur

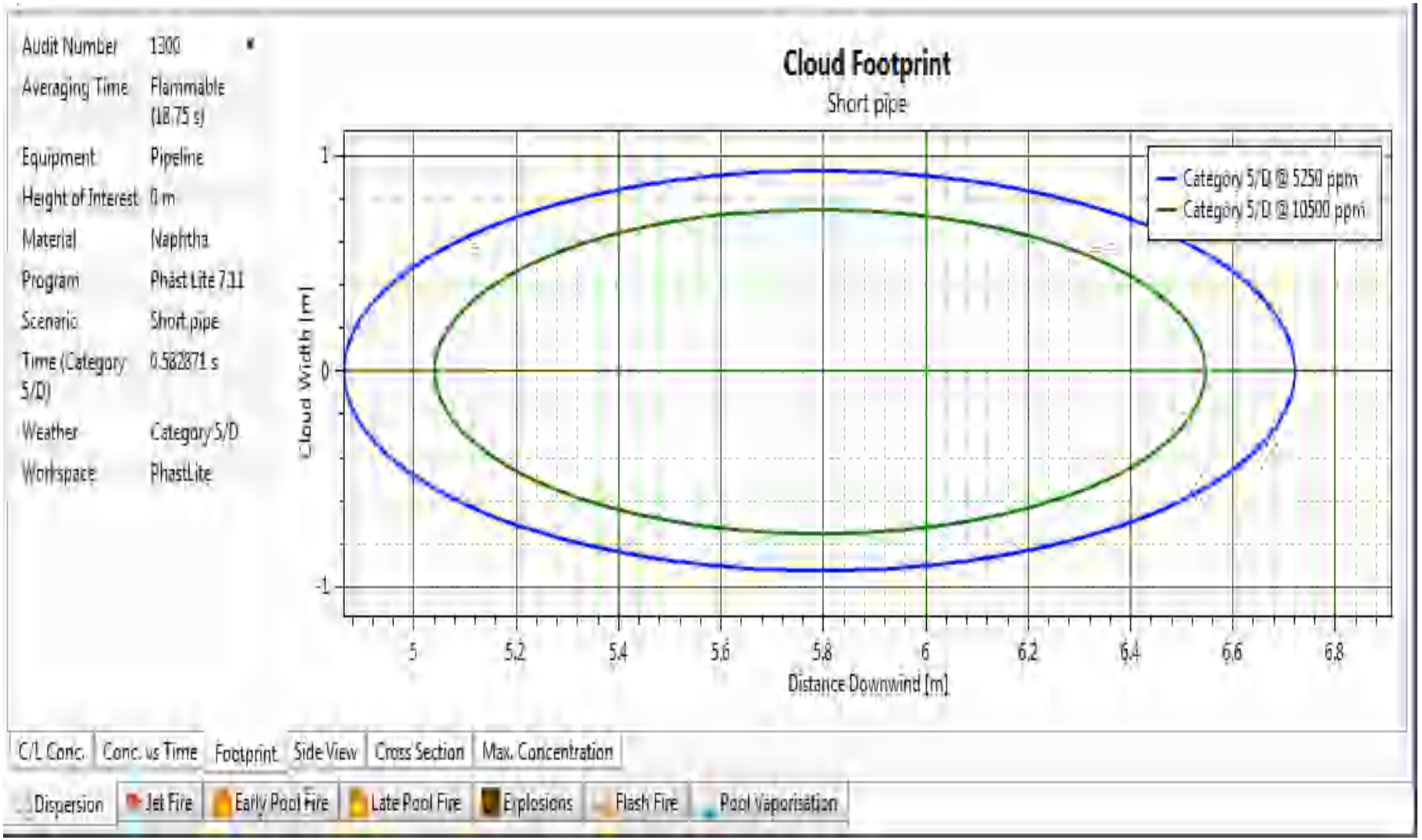


Figure 46:- Graph showing rupture of Cloud footprint from pipeline of Sidhpur station.

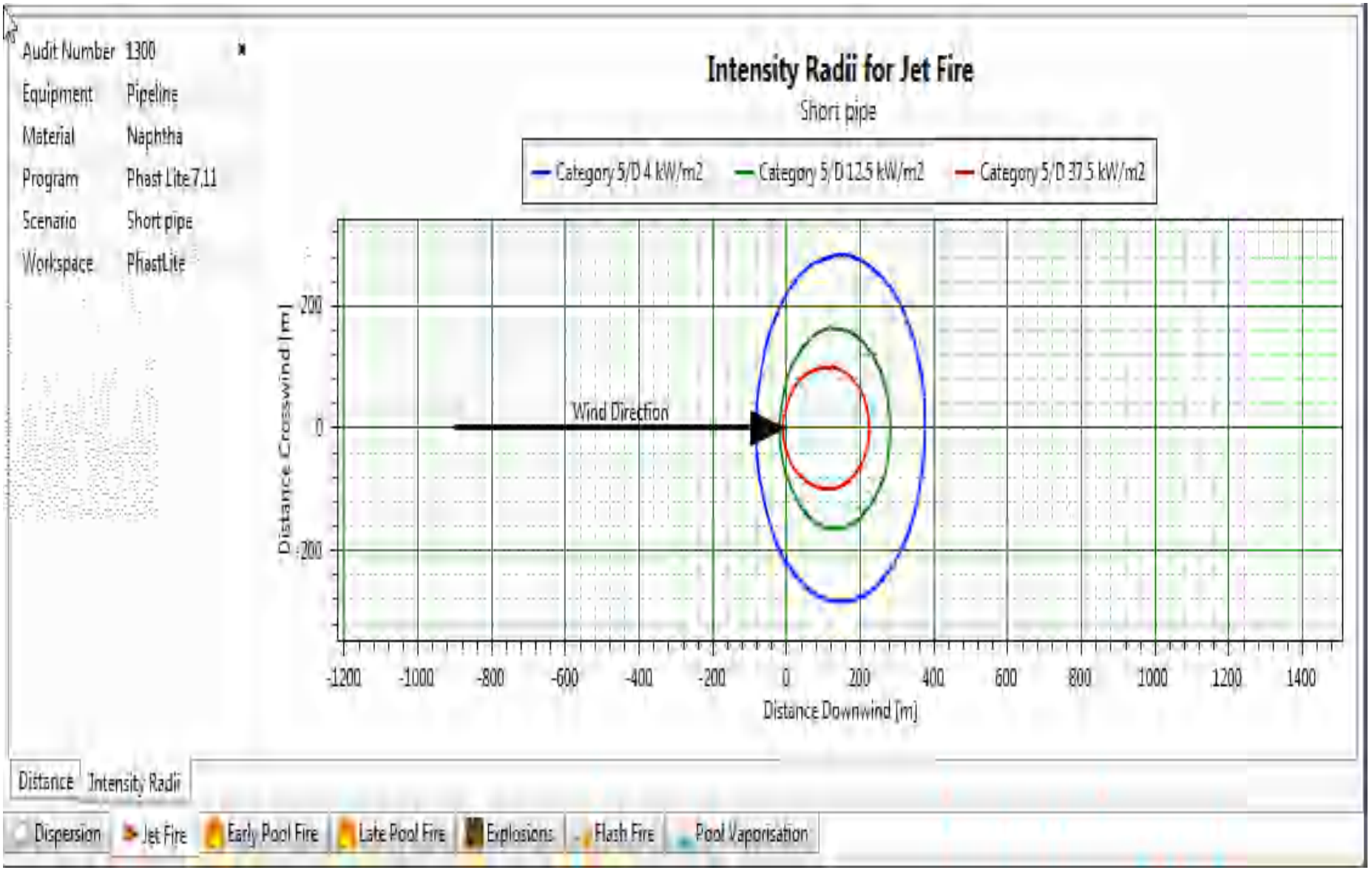


Figure 47:- Graph showing rupture of Intensity Radii for Jet Fire from pipeline of Sidhpur station.

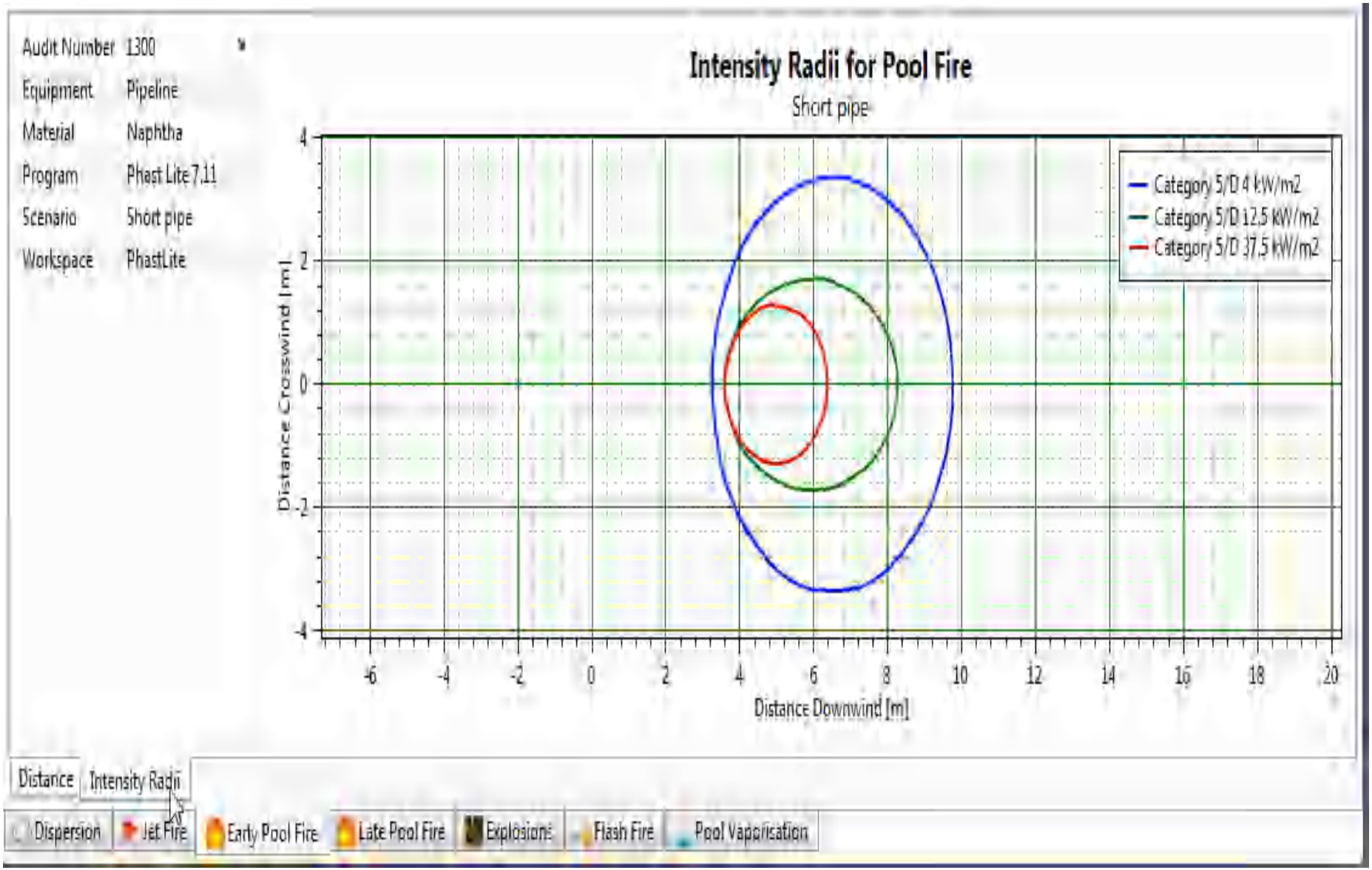


Figure 48:- Graph showing rupture of Intensity Radii for Pool Fire from pipeline of Sidhpur station.

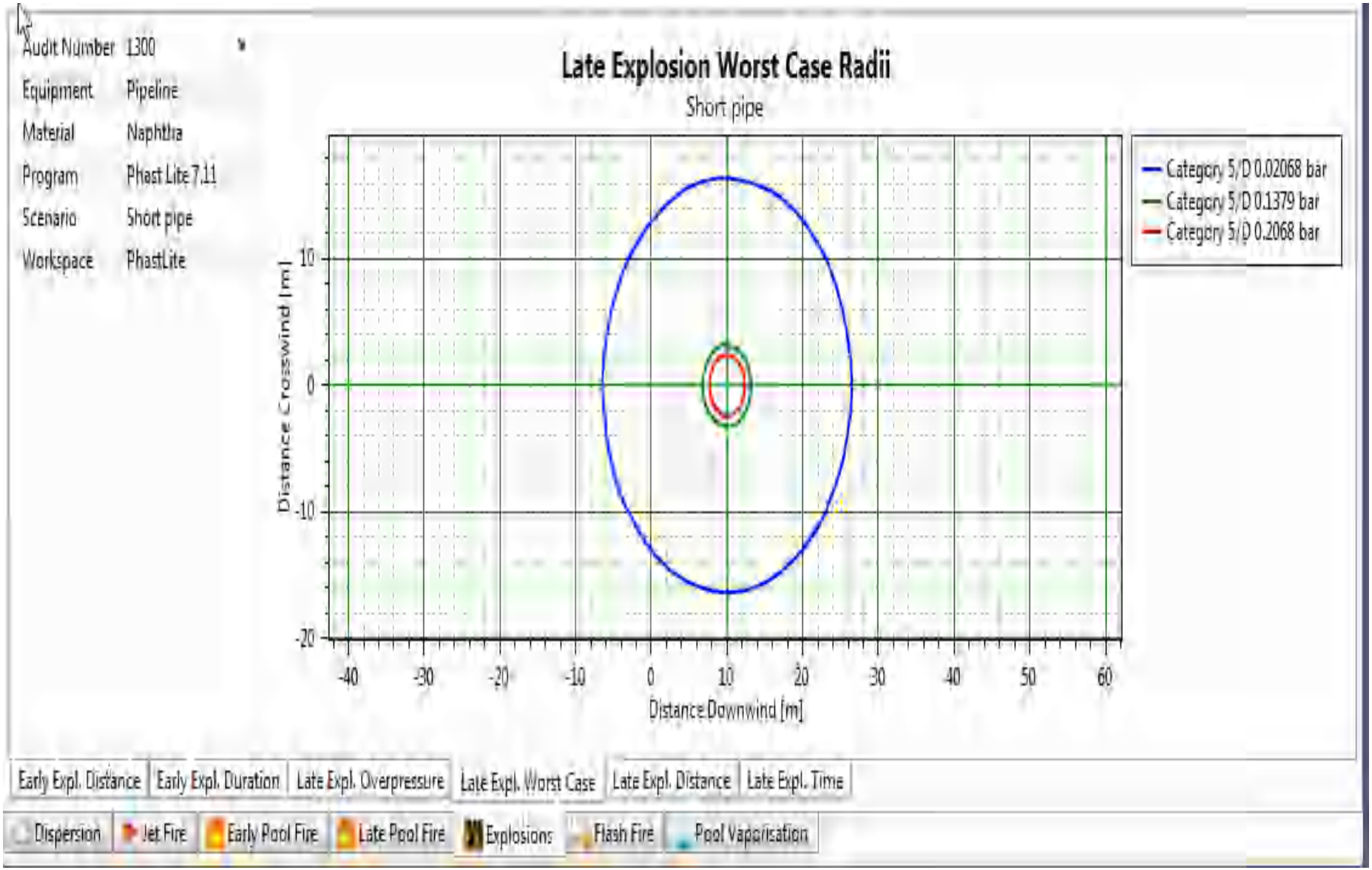


Figure 49:- Rupture graph of Late explosion Worst Case Radii from pipeline of Sidhpur station.

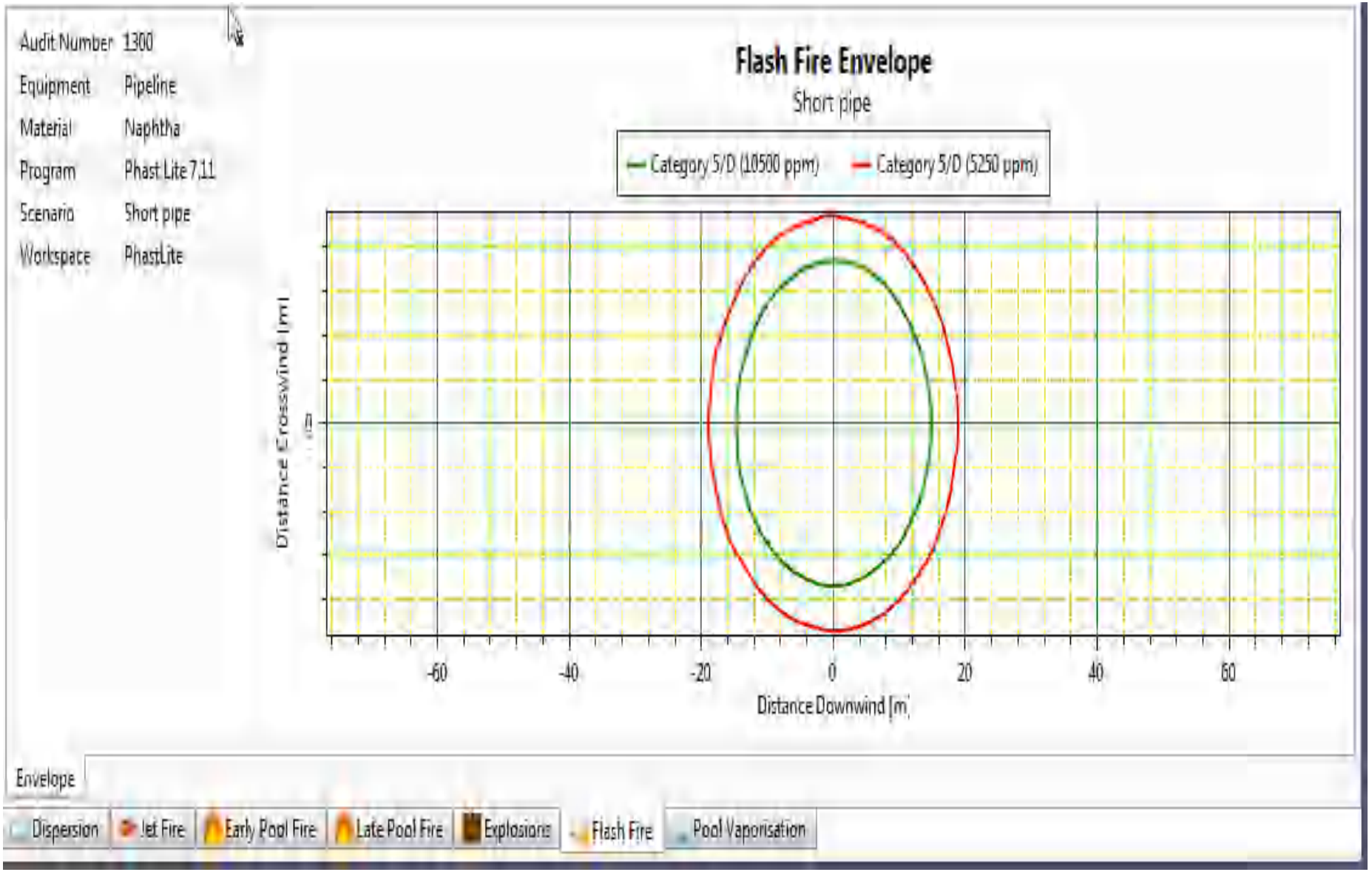


Figure 50:- Rupture graph of Flash fire envelope for Jet Fire from pipeline of Sidhpur station.

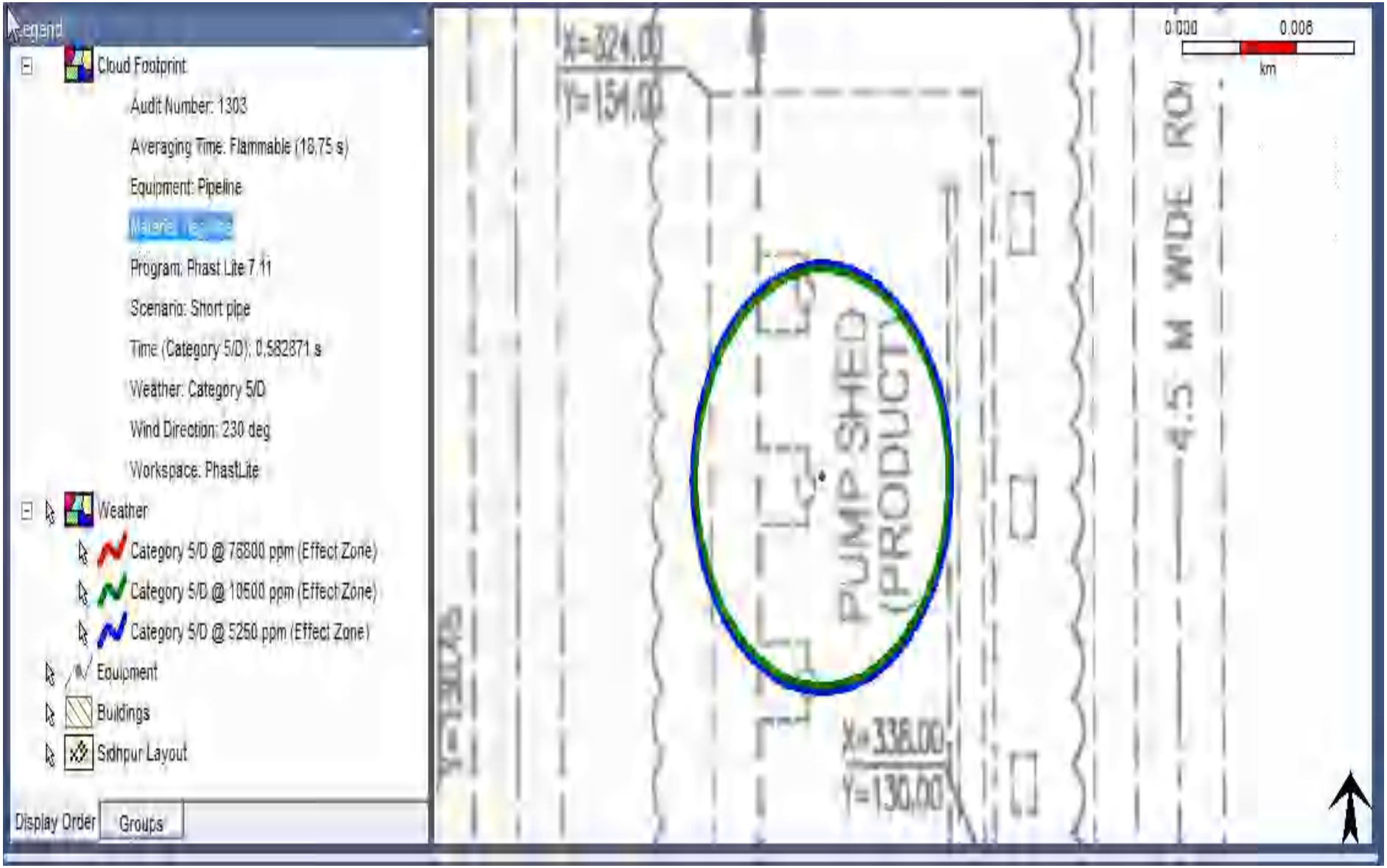


Figure 51:- Cloud footprint of Sidhpur station (Rupture of pipeline)

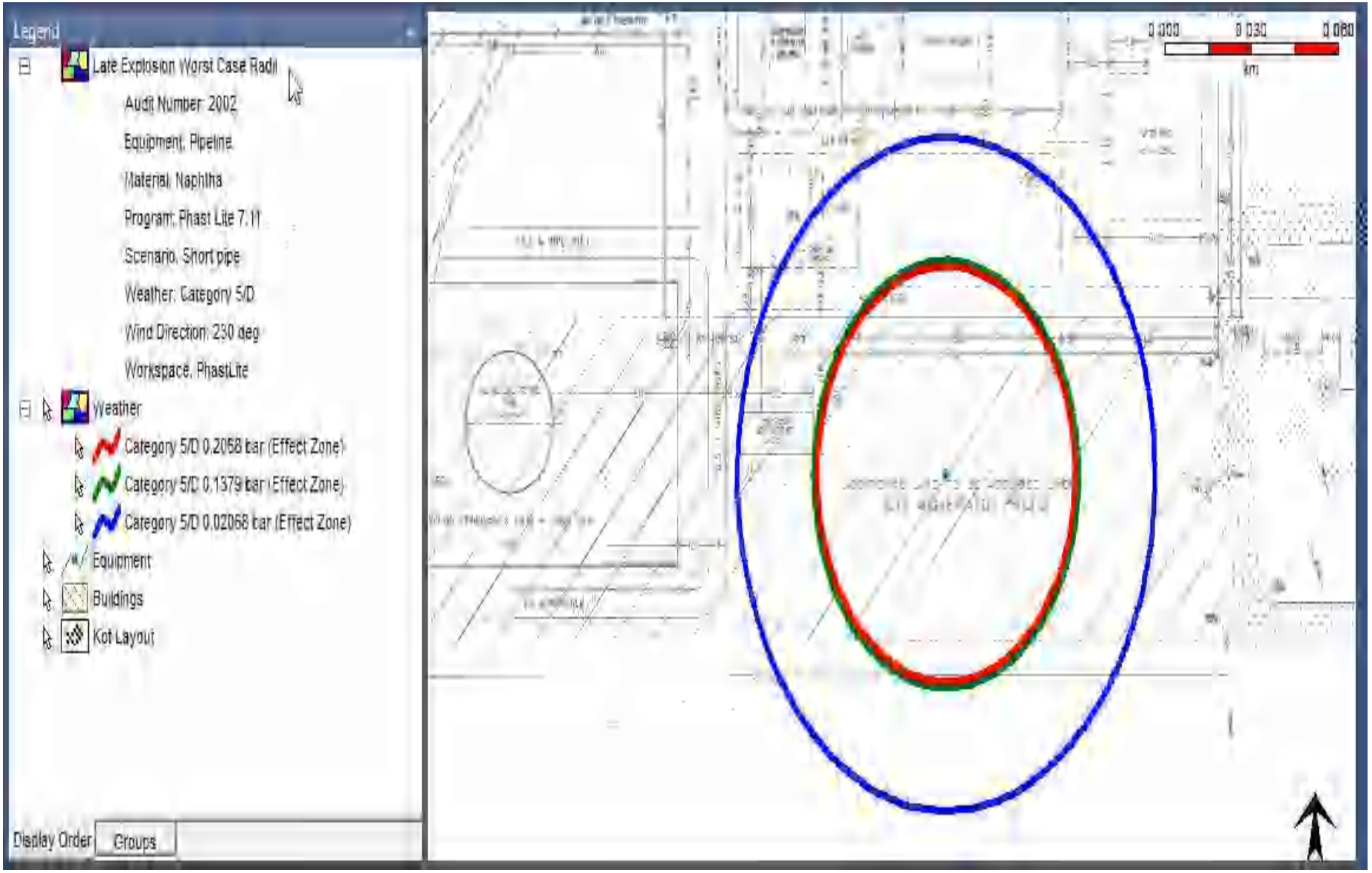


Figure 52:- Late Explosion Worst case Radii of Kot station (Rupture of pipeline)

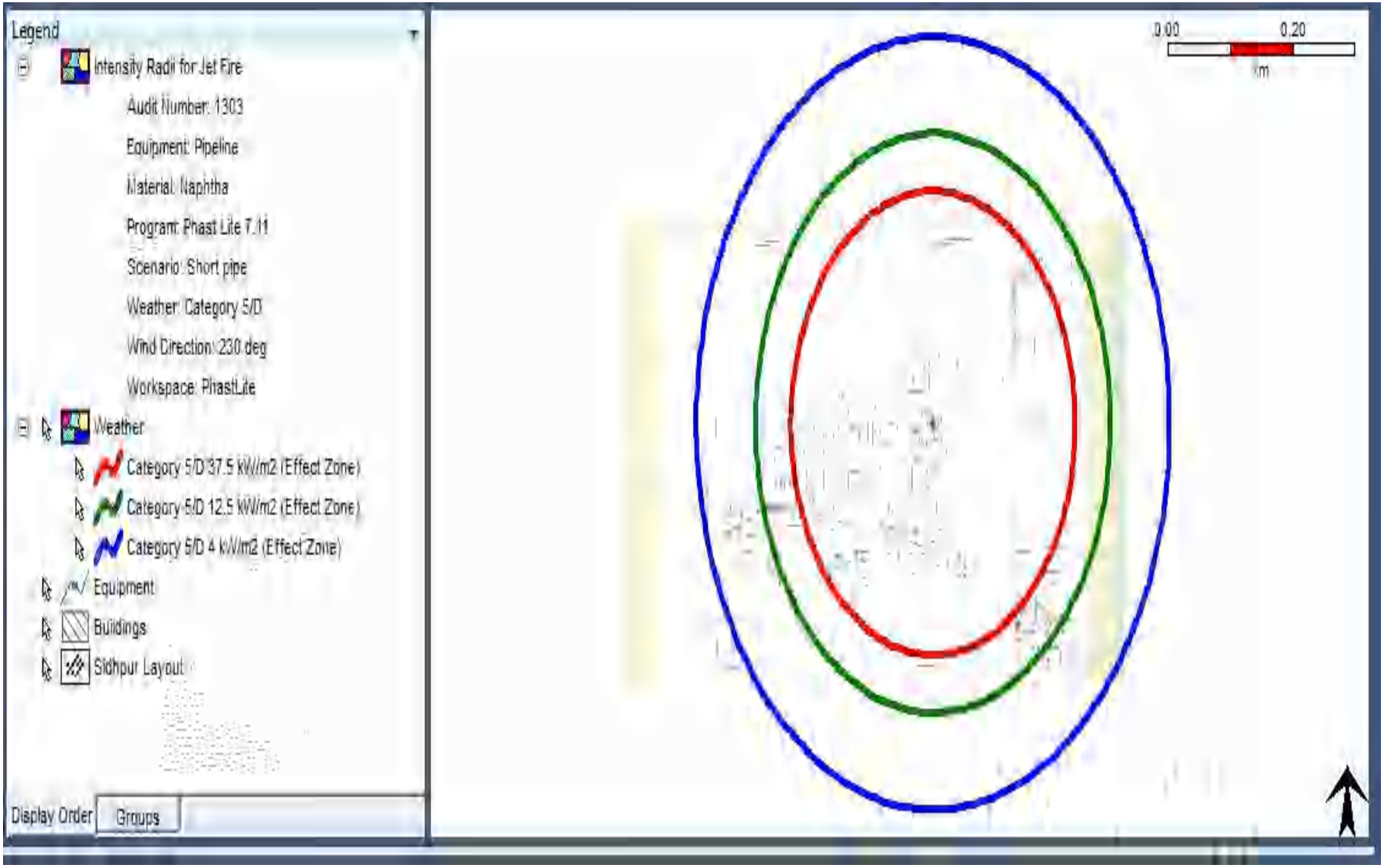


Figure 53:- Intensity Radii for Jet fire of Sidhpur station (Rupture of pipeline)

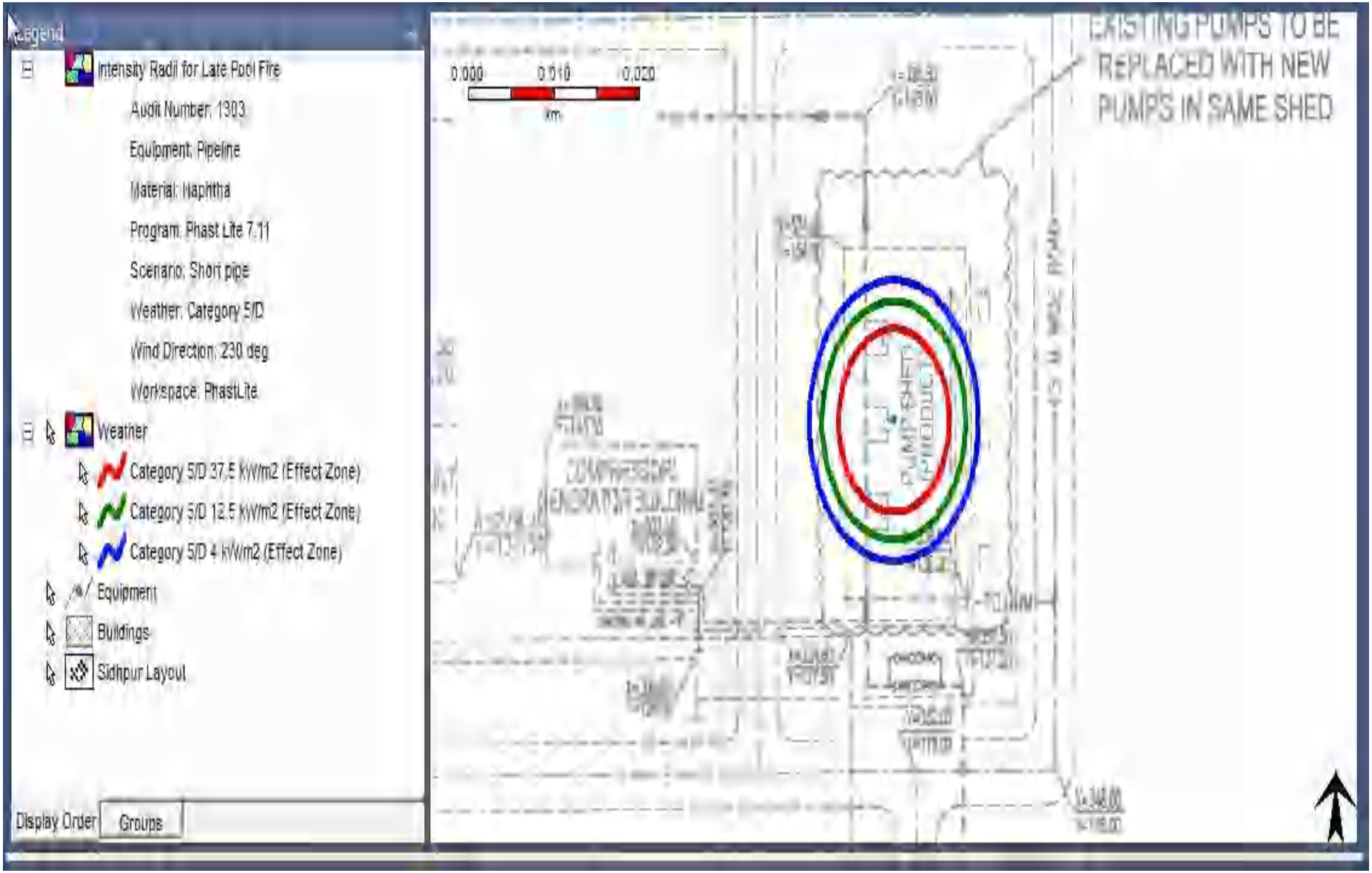


Figure 54:- Intensity Radii for late Pool Fire of Sidhpur station (Rupture of pipeline)

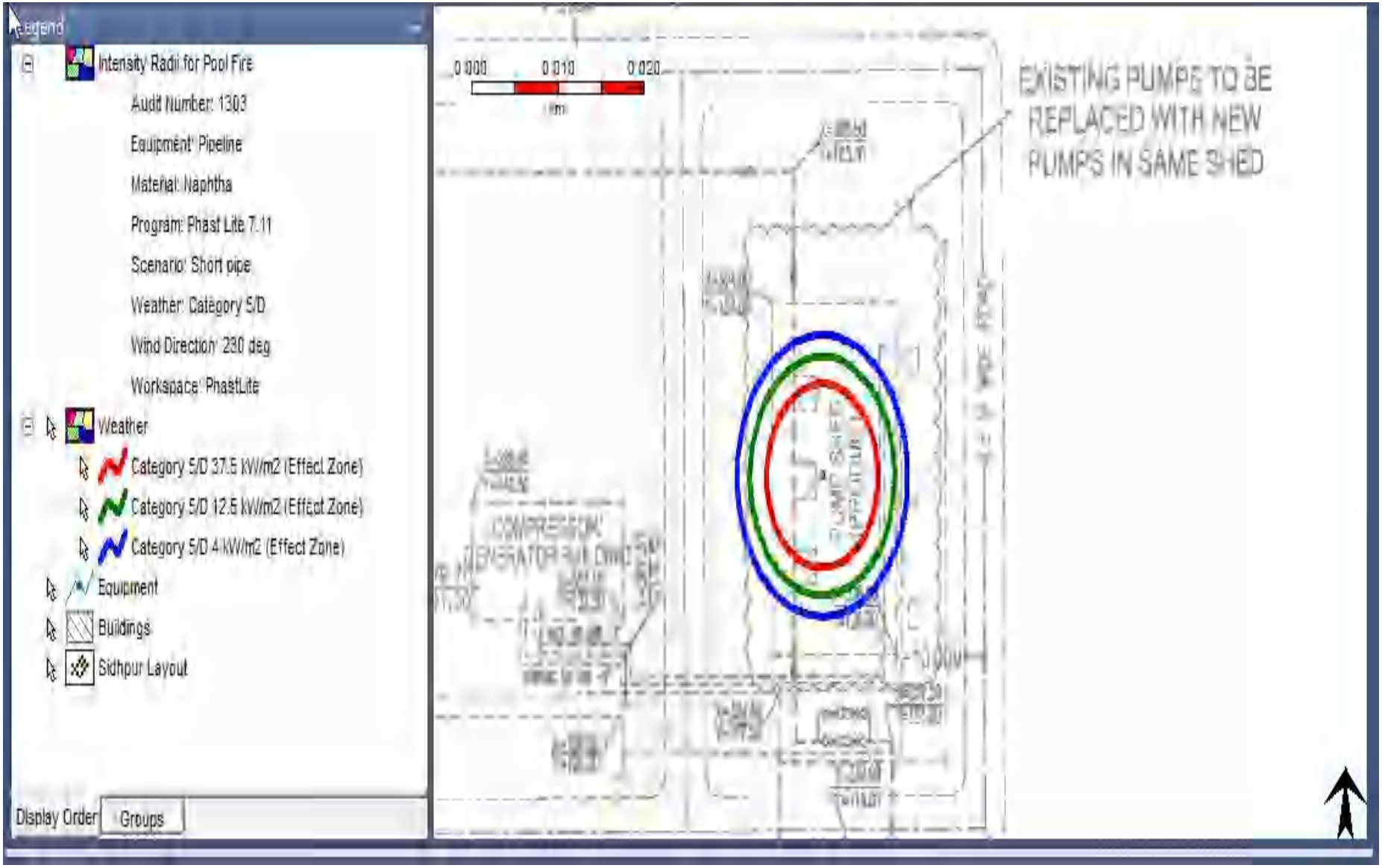


Figure 55:- Intensity Radii for Pool Fire of Sidhpur station (Rupture of pipeline)

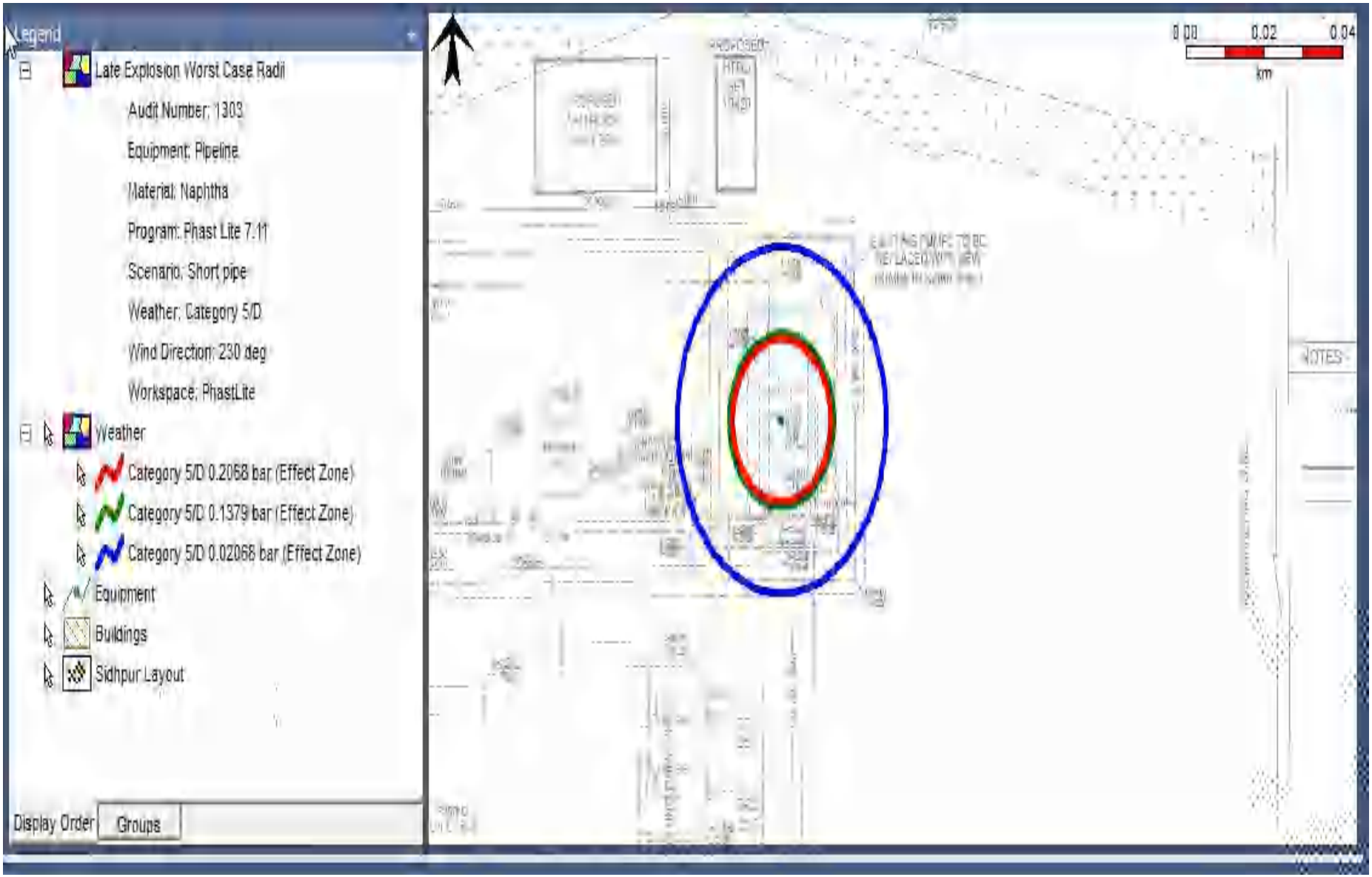


Figure 56:- Late Explosion Worst Case Radii of Sidhpur station (Rupture of pipeline)

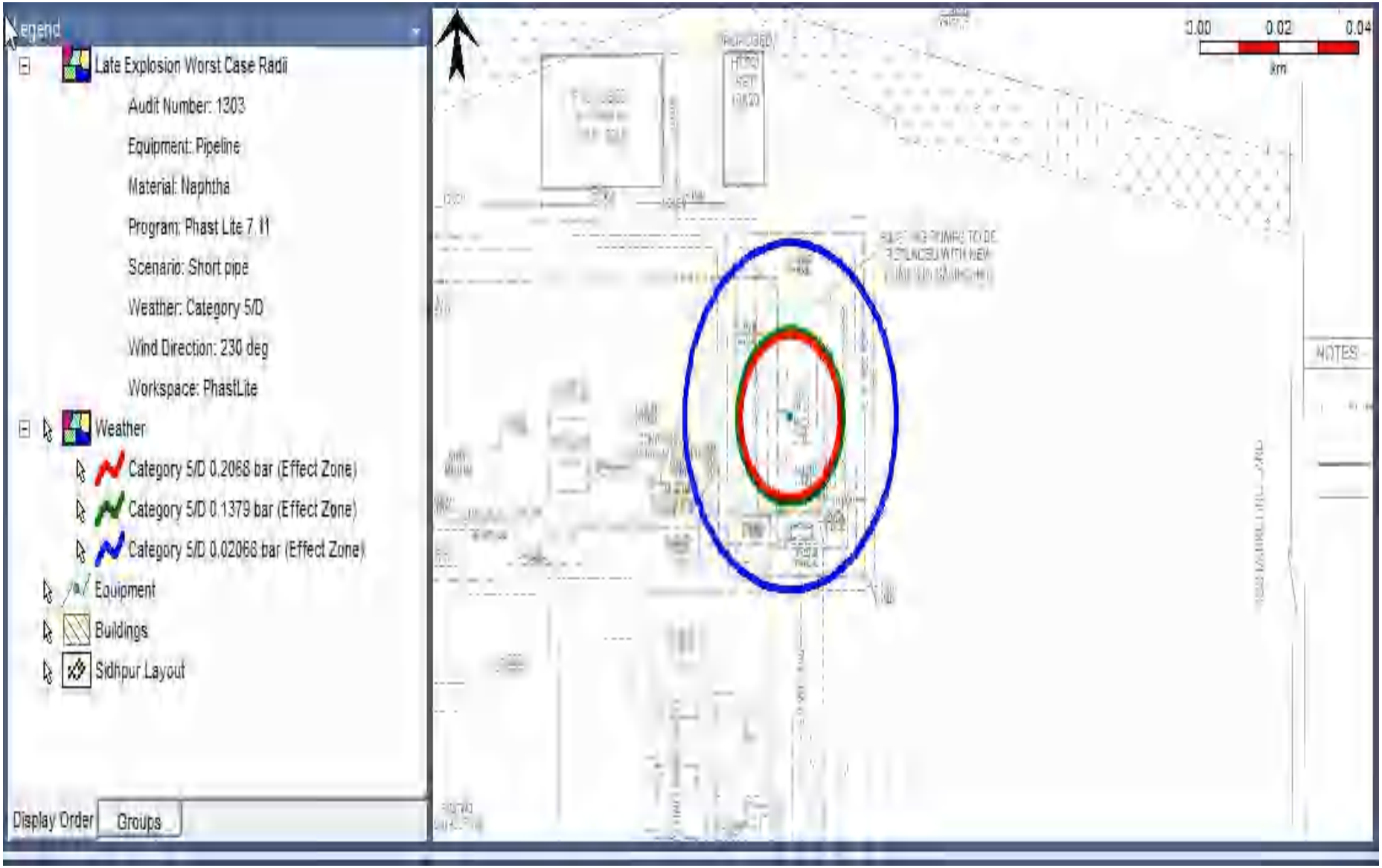


Figure 57:- Late Explosion Worst Case Radii of Sidhpur station (Rupture of pipeline)

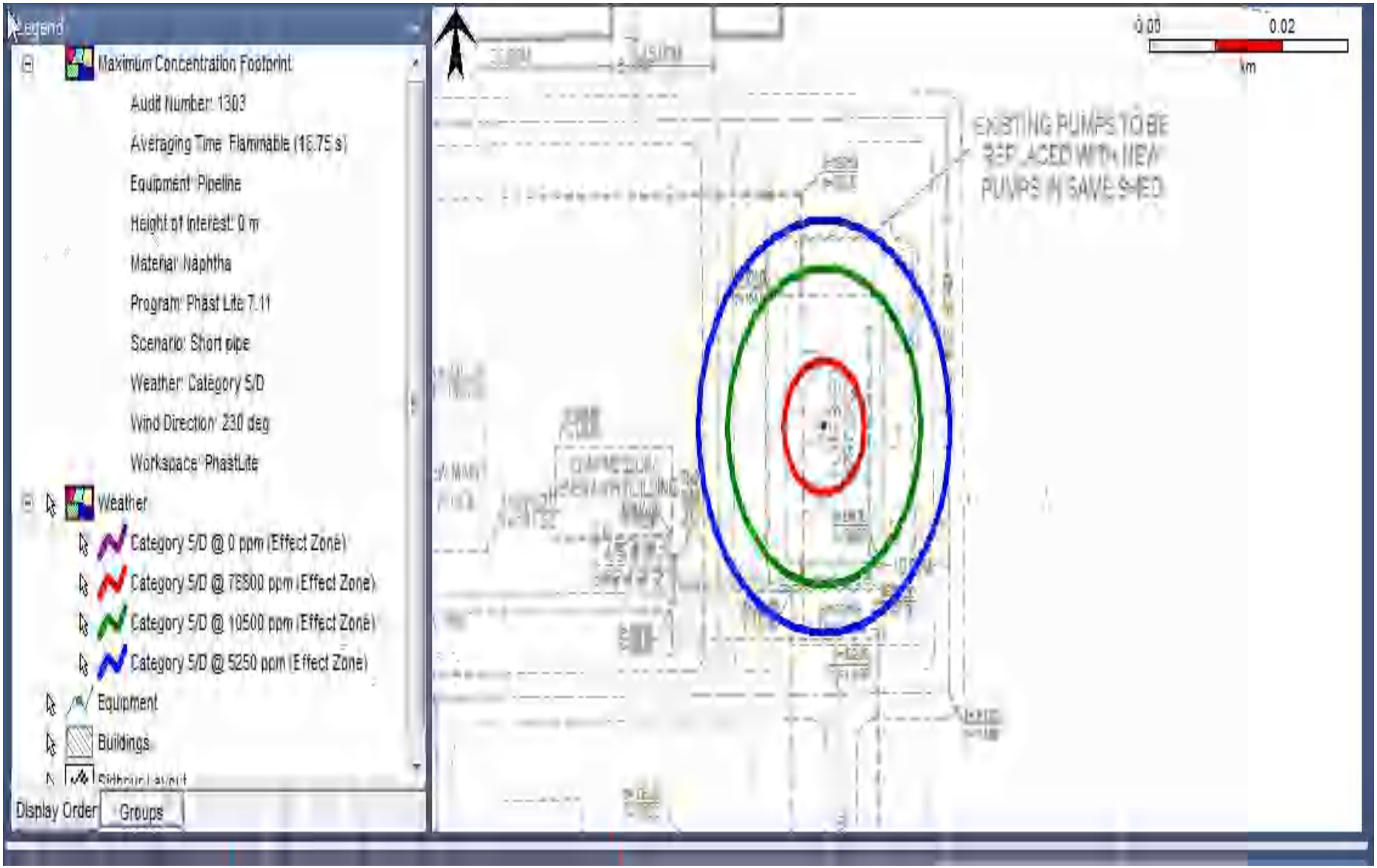


Figure 58:- Maximum Concentration footprint of Sidhpur station (Rupture of pipeline)

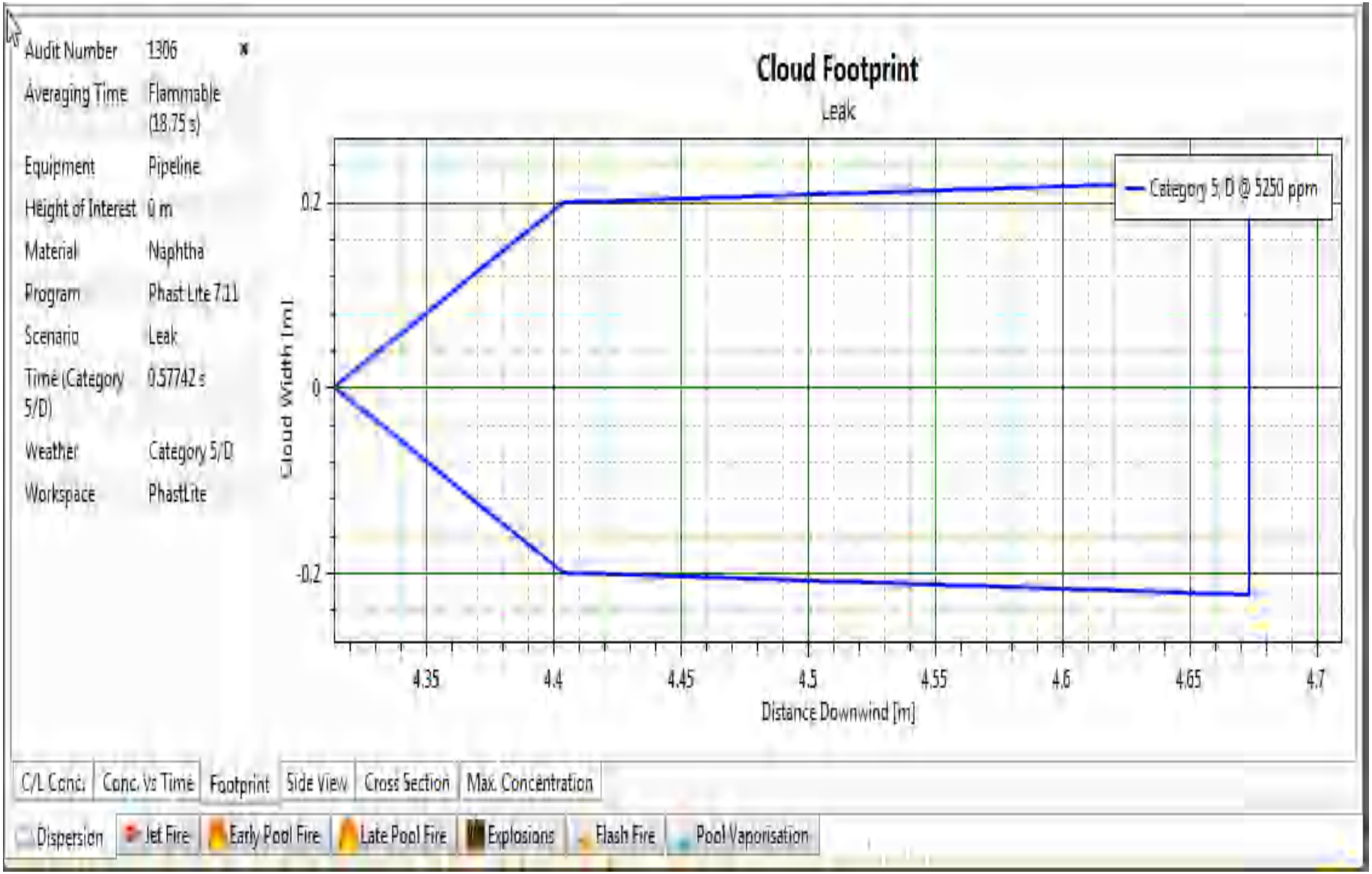


Figure 59:- Graph showing leak of Cloud Footprint from pipeline of Sidhpur station.

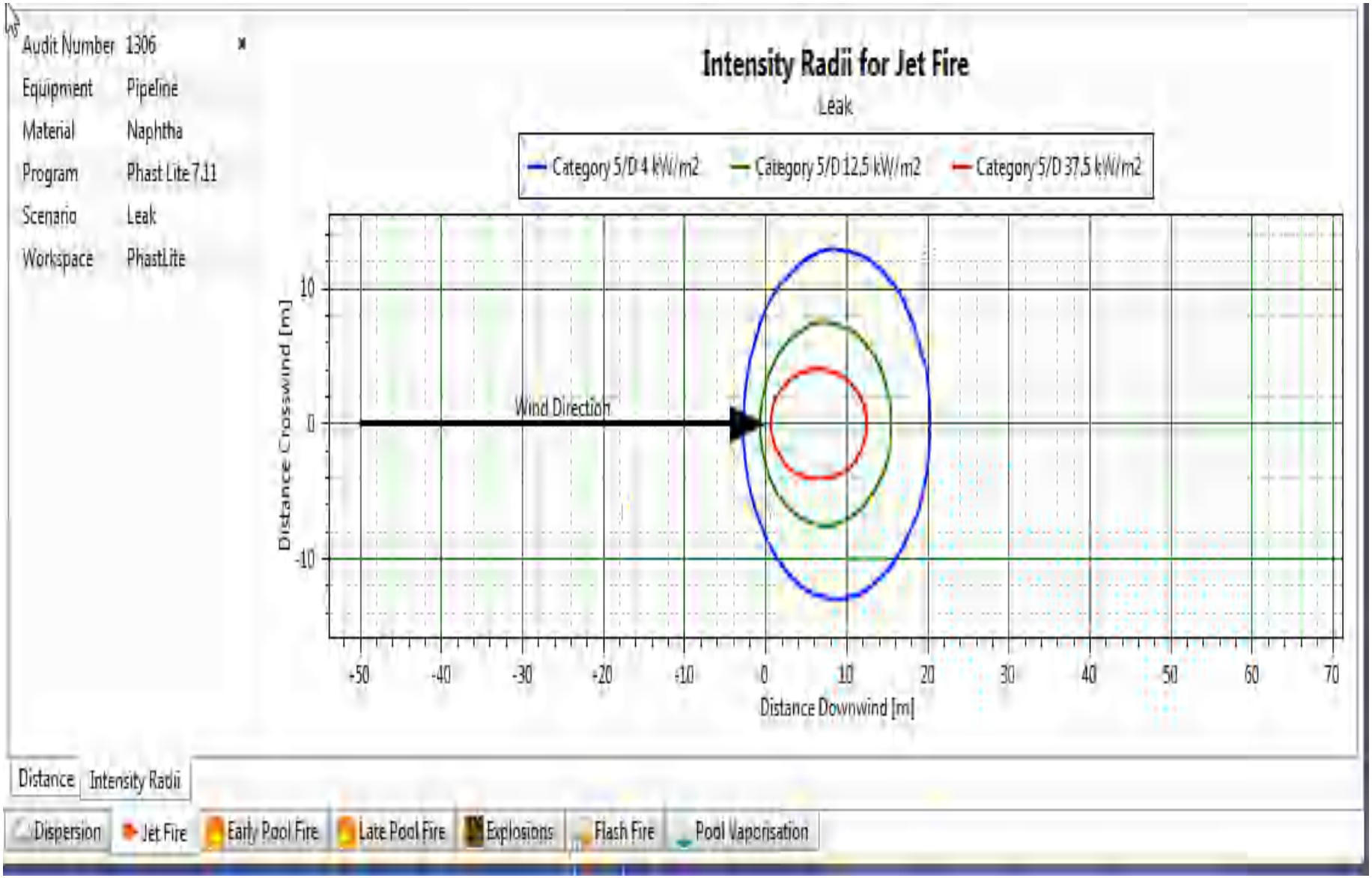


Figure 60:- Graph showing leak of Intensity Radii for Jet fire from pipeline of Sidhpur station.

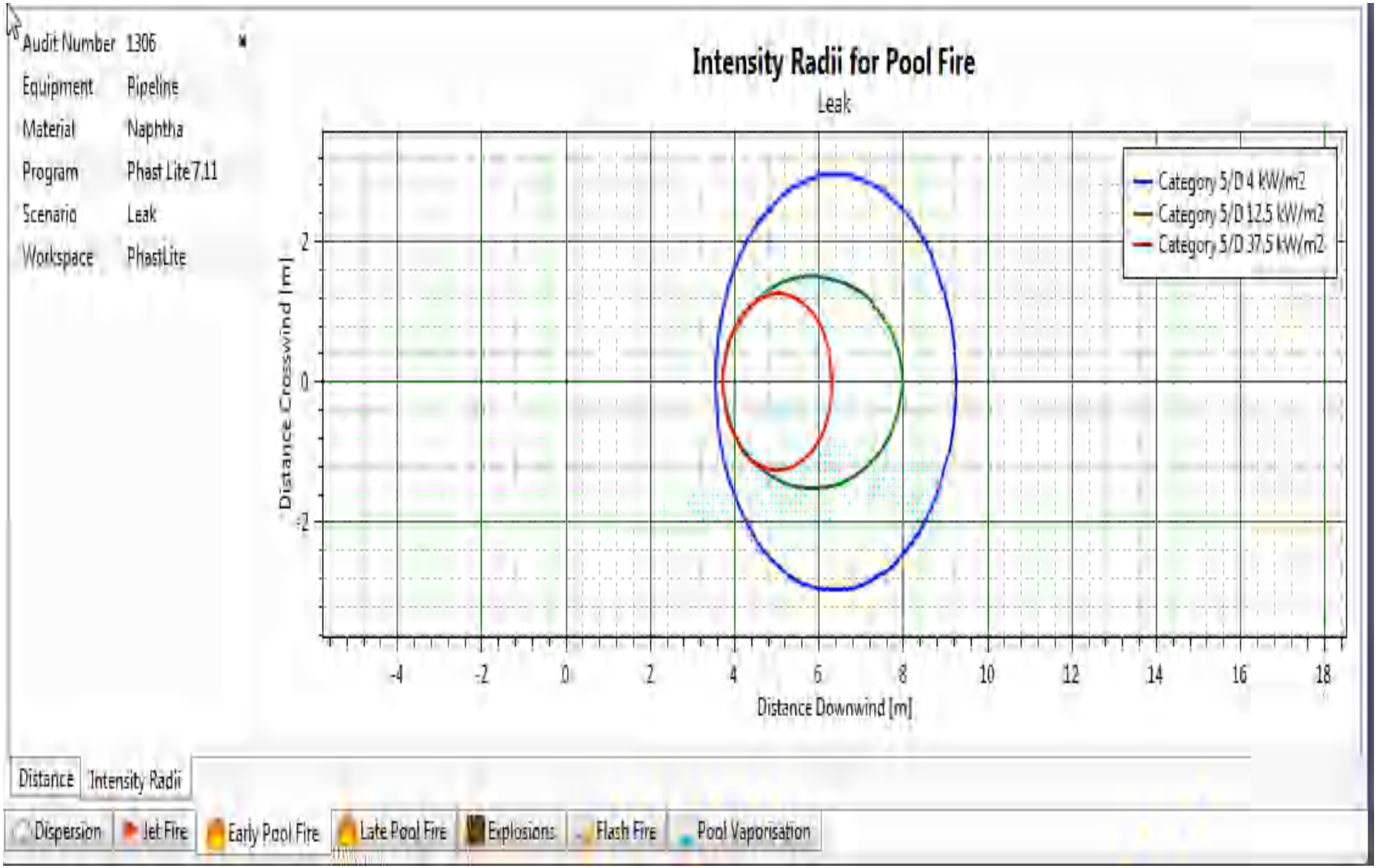


Figure 61:- Graph showing leak of Intensity Radii for Pool Fire from pipeline of Sidhpur station.

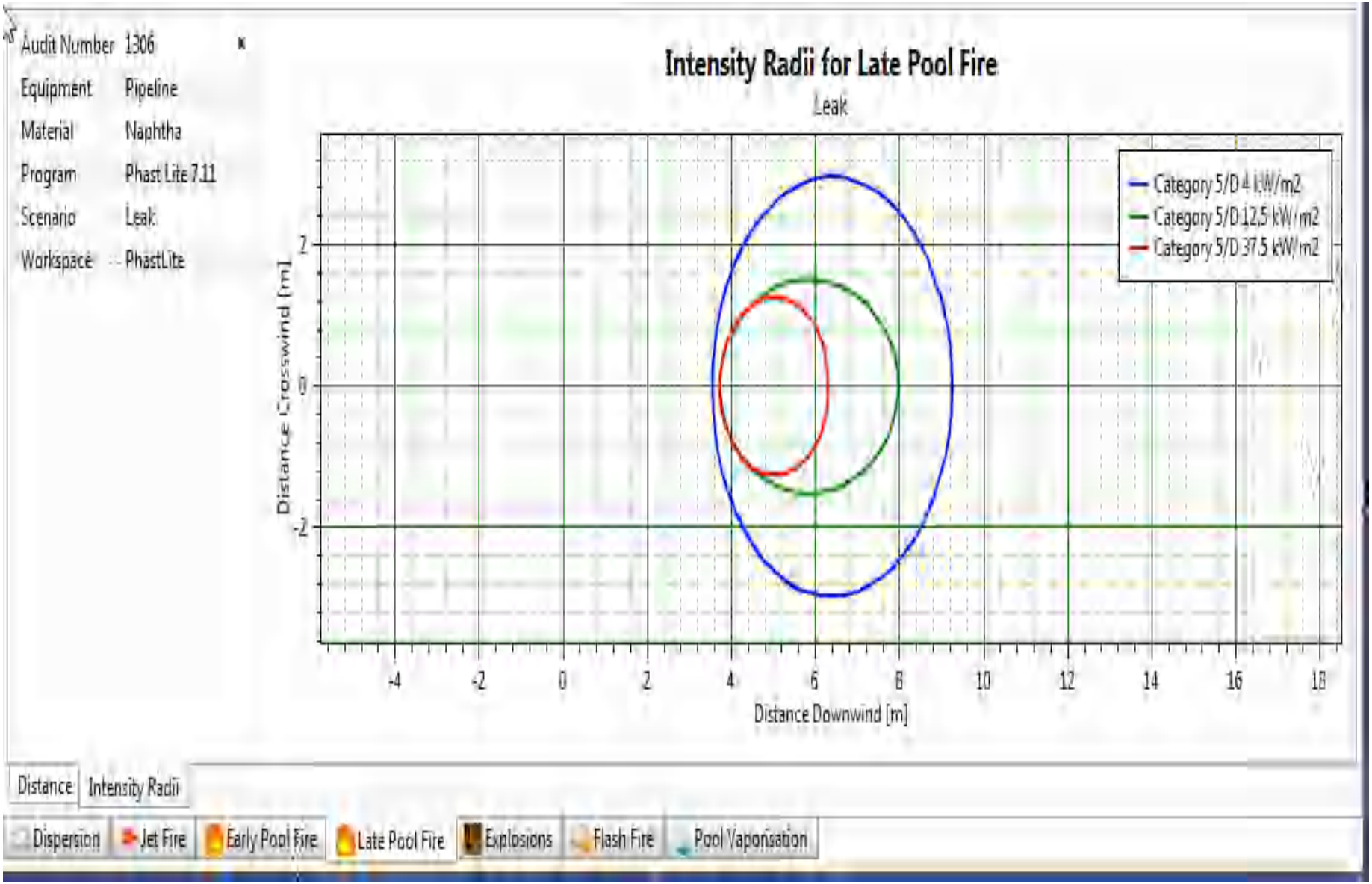


Figure 62:- Graph showing leak of Intensity Radii for Pool Fire from pipeline of Sidhpur station.

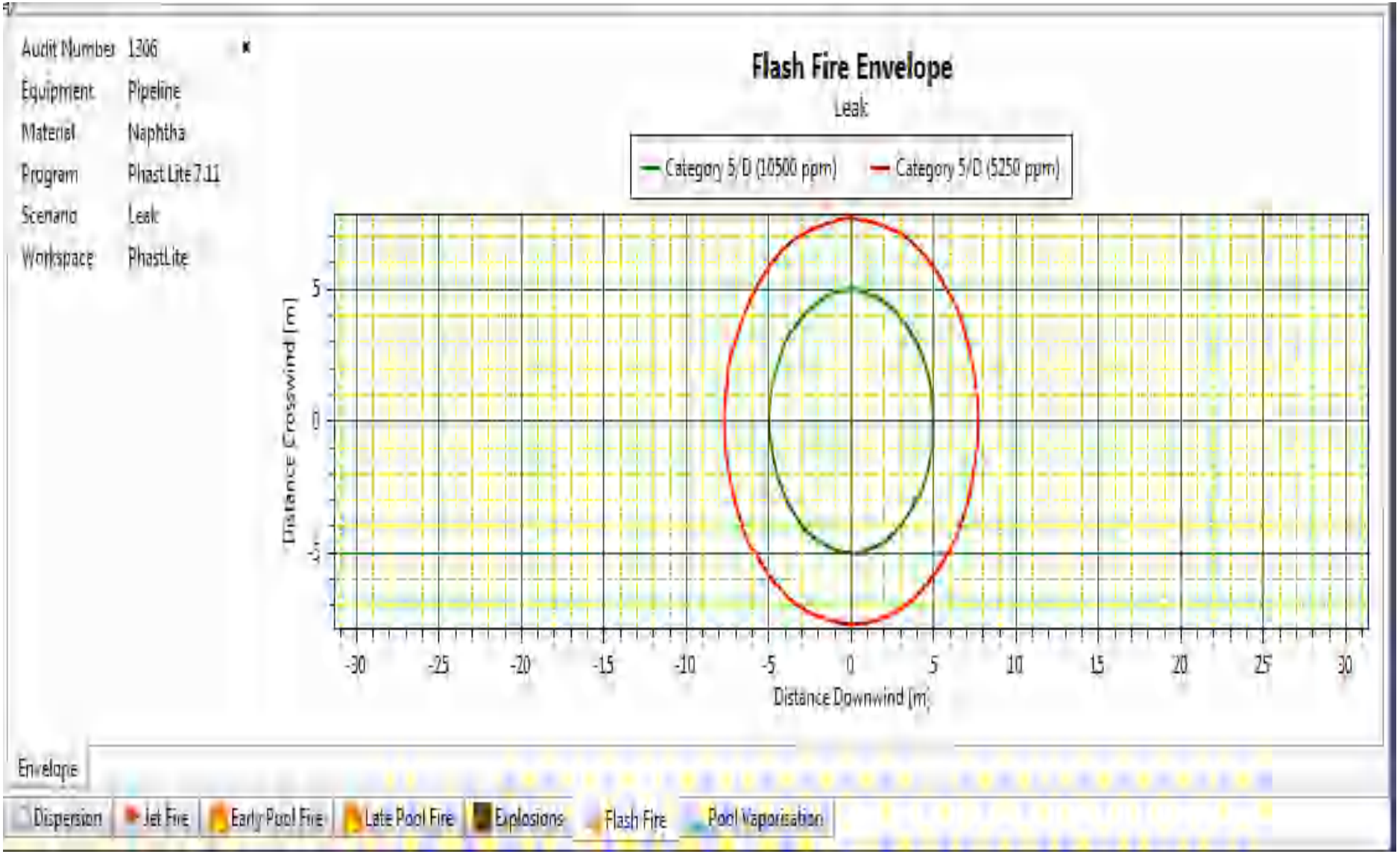


Figure 63:- Graph showing leak of Flash Fire Envelope from pipeline of Sidhpur station.

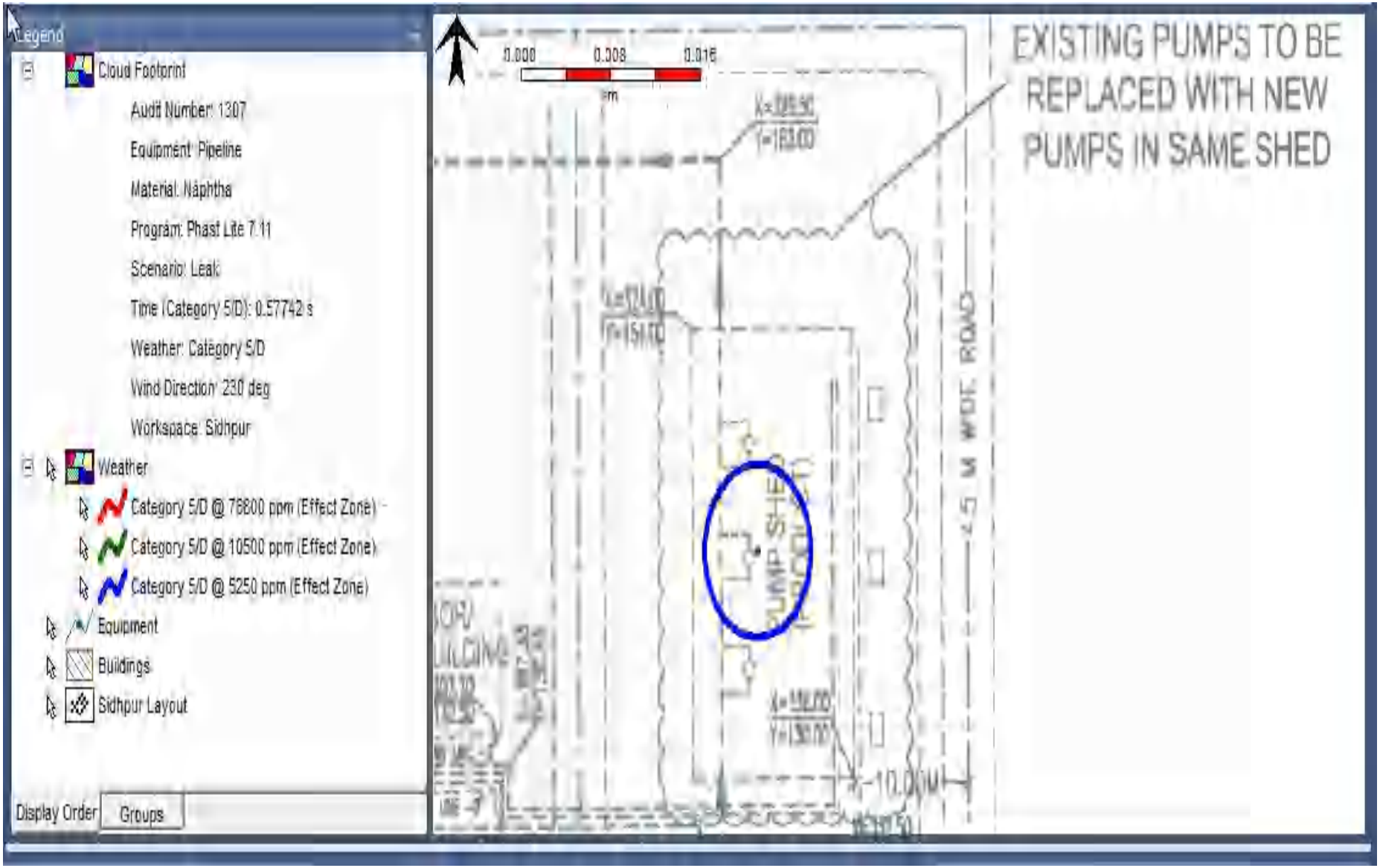


Figure 64:- Cloud Footprint of Sidhpur station (Leak of pipeline)

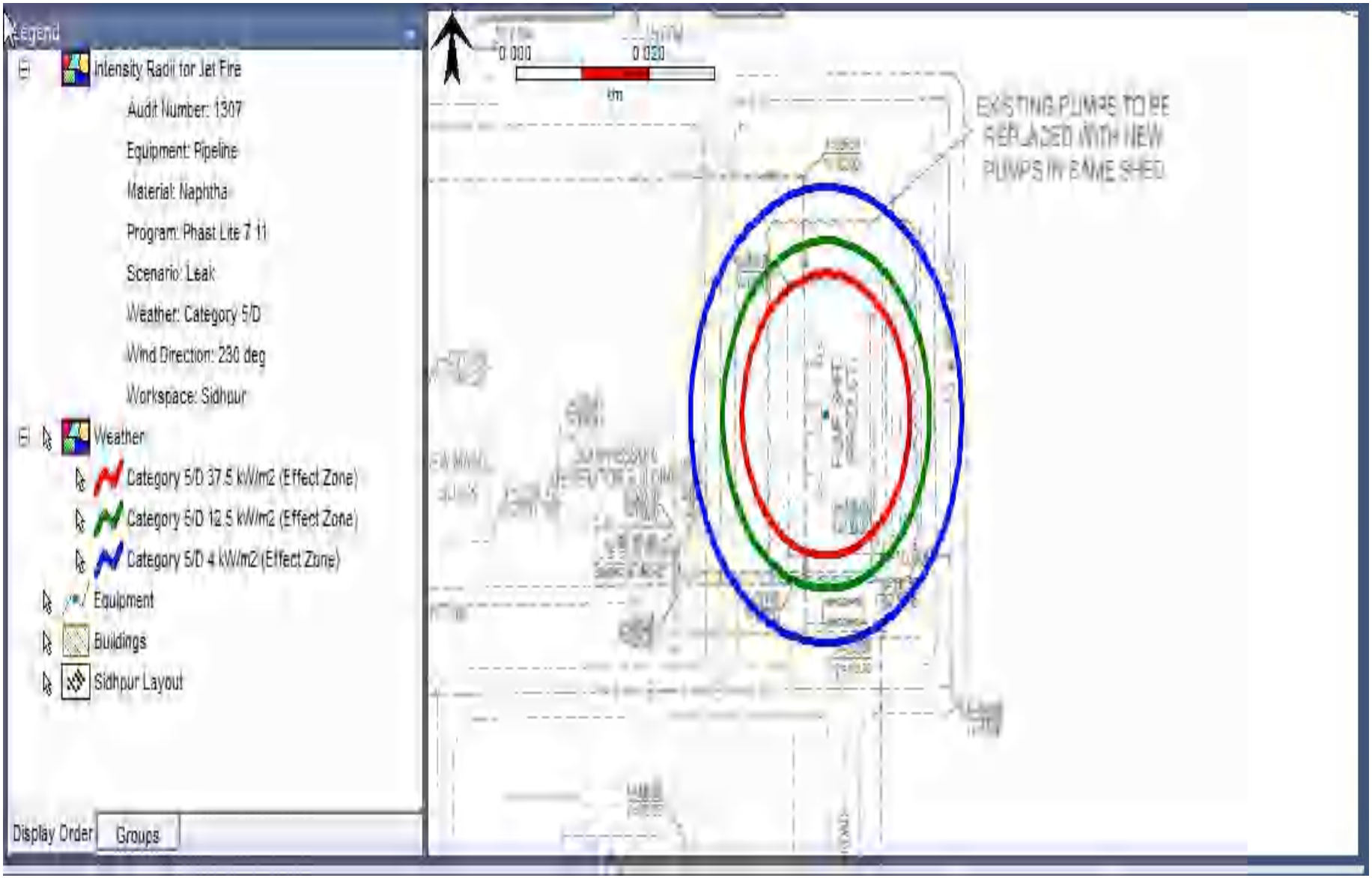


Figure 65:- Intensity radii for Jet Fire of Sidhpur station (Leak of pipeline)

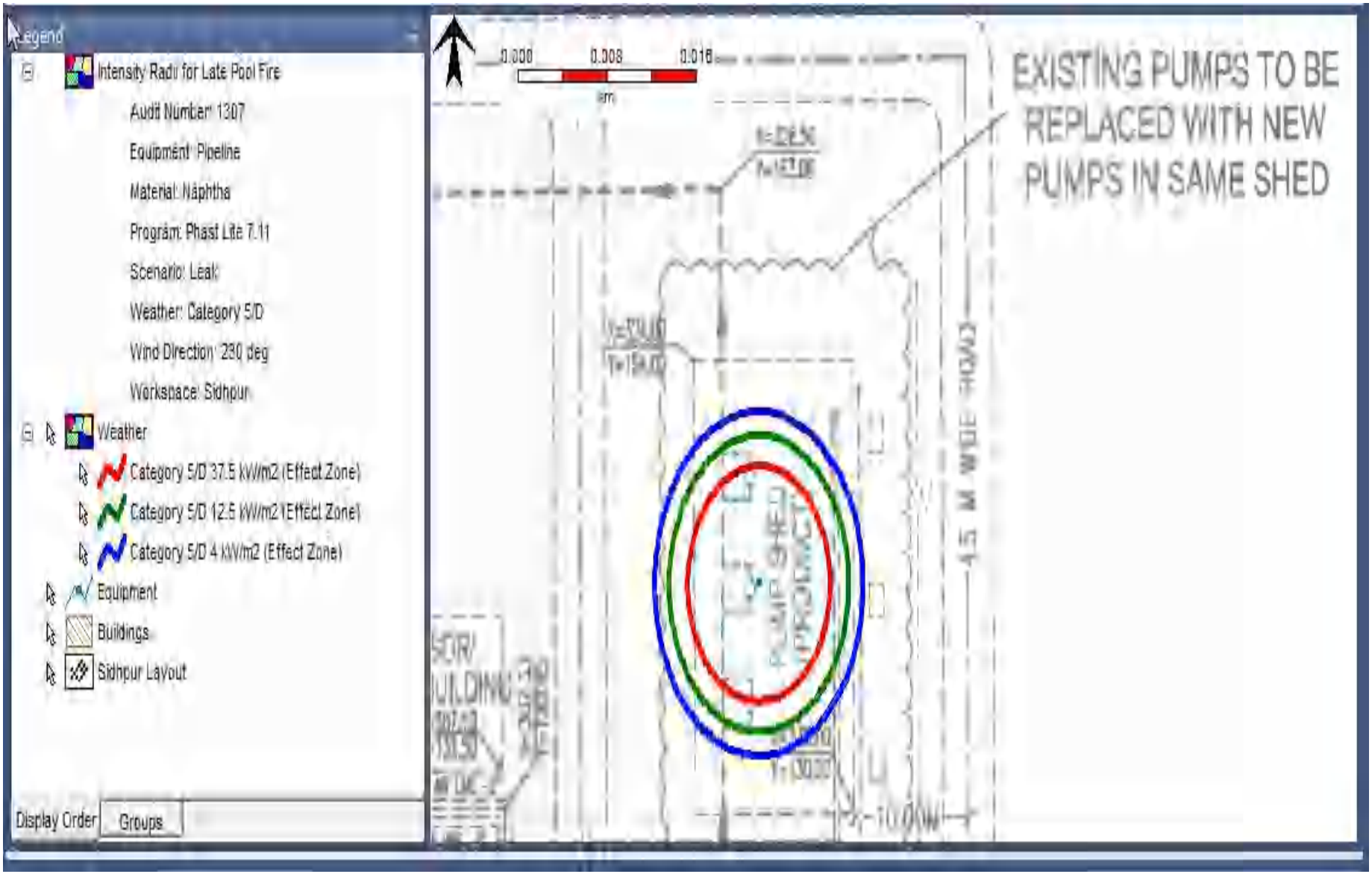


Figure 66:- Intensity Radii for Late Pool fire of Sidhpur station (Leak of pipeline)

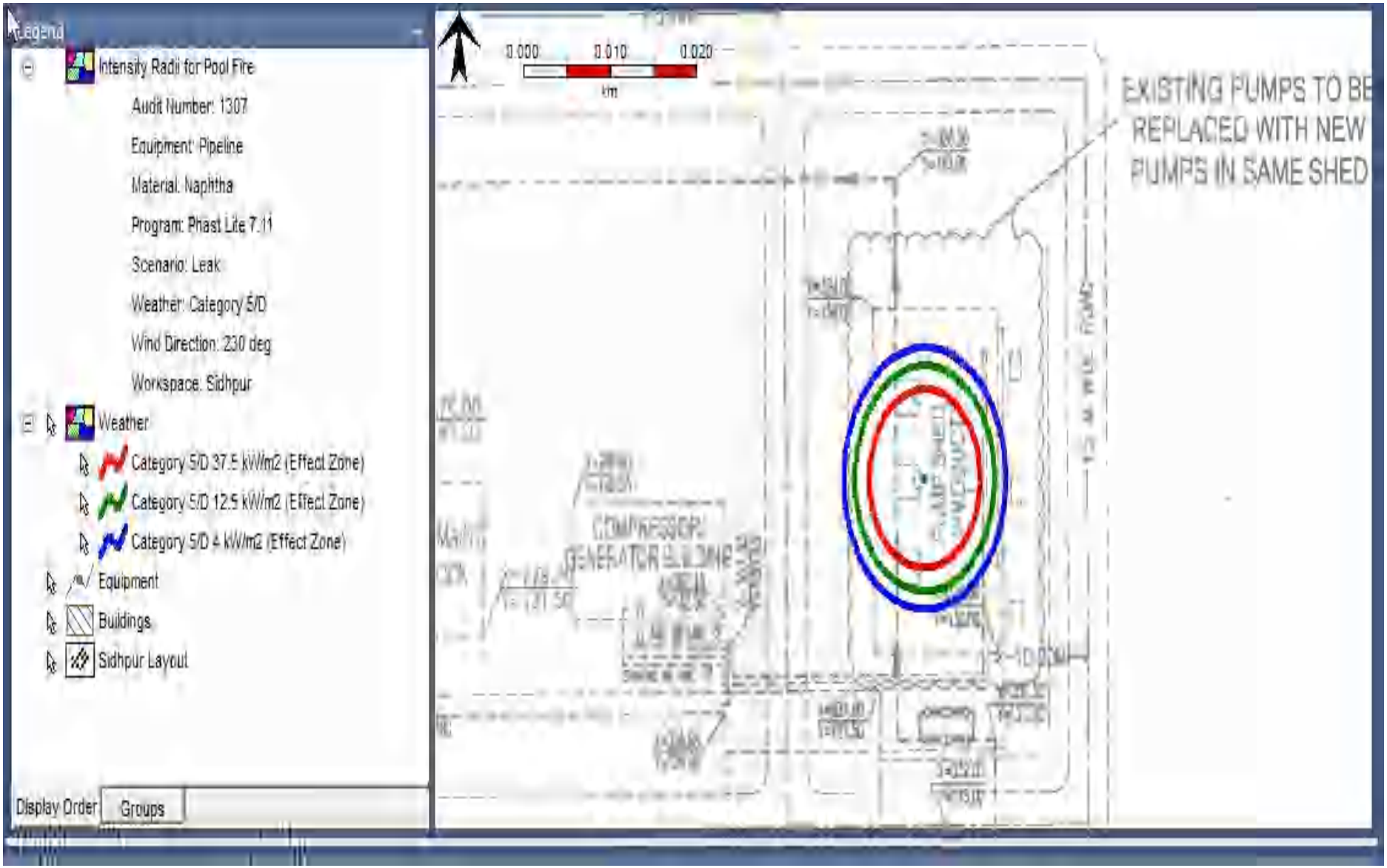


Figure 67:- Intensity radii for Pool Fire of Sidhpur station (Leak of pipeline)

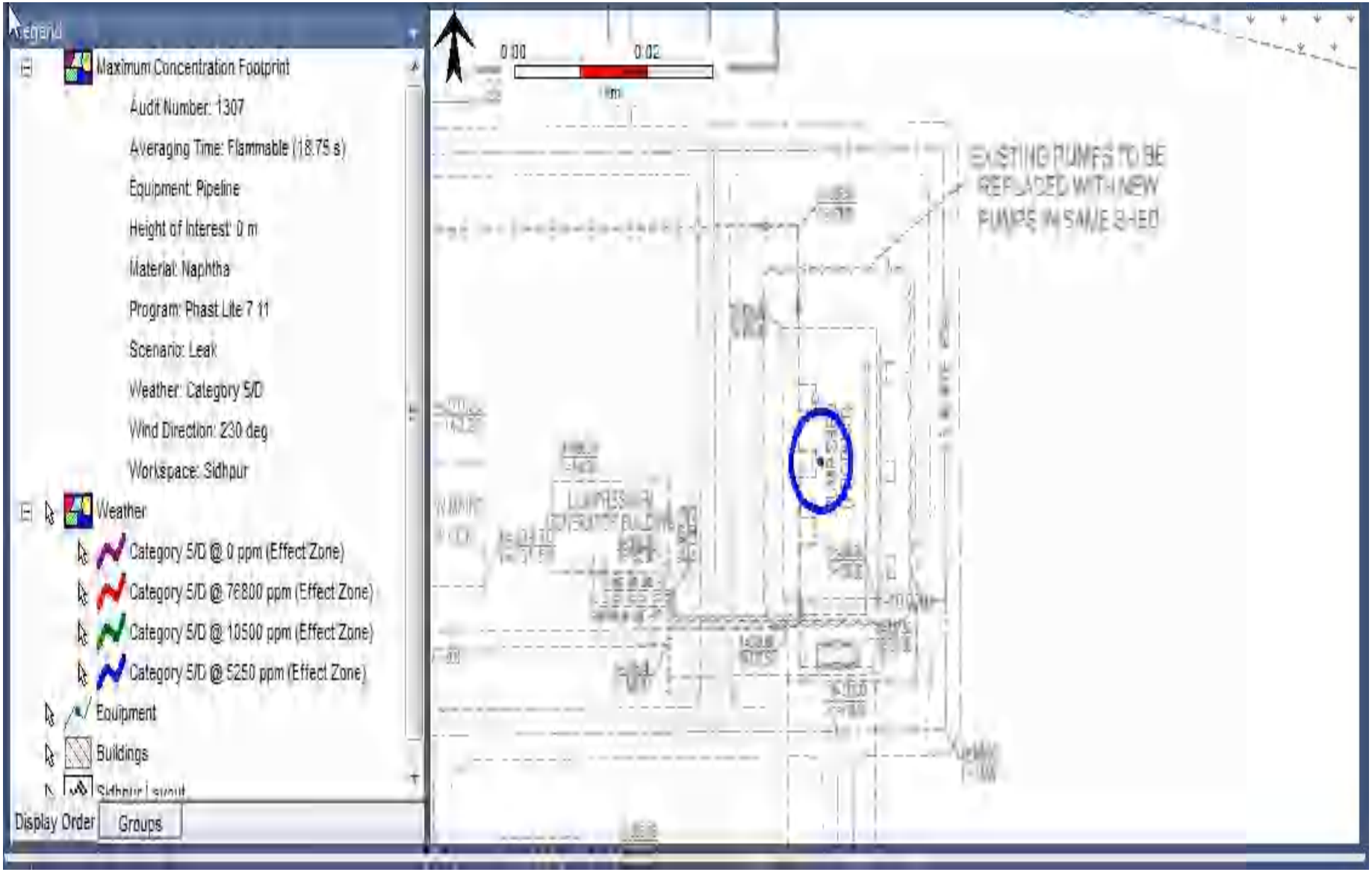


Figure 68:- Maximum Concentration Footprint of Sidhpur station (Leak of pipeline)

KOT (LBT)

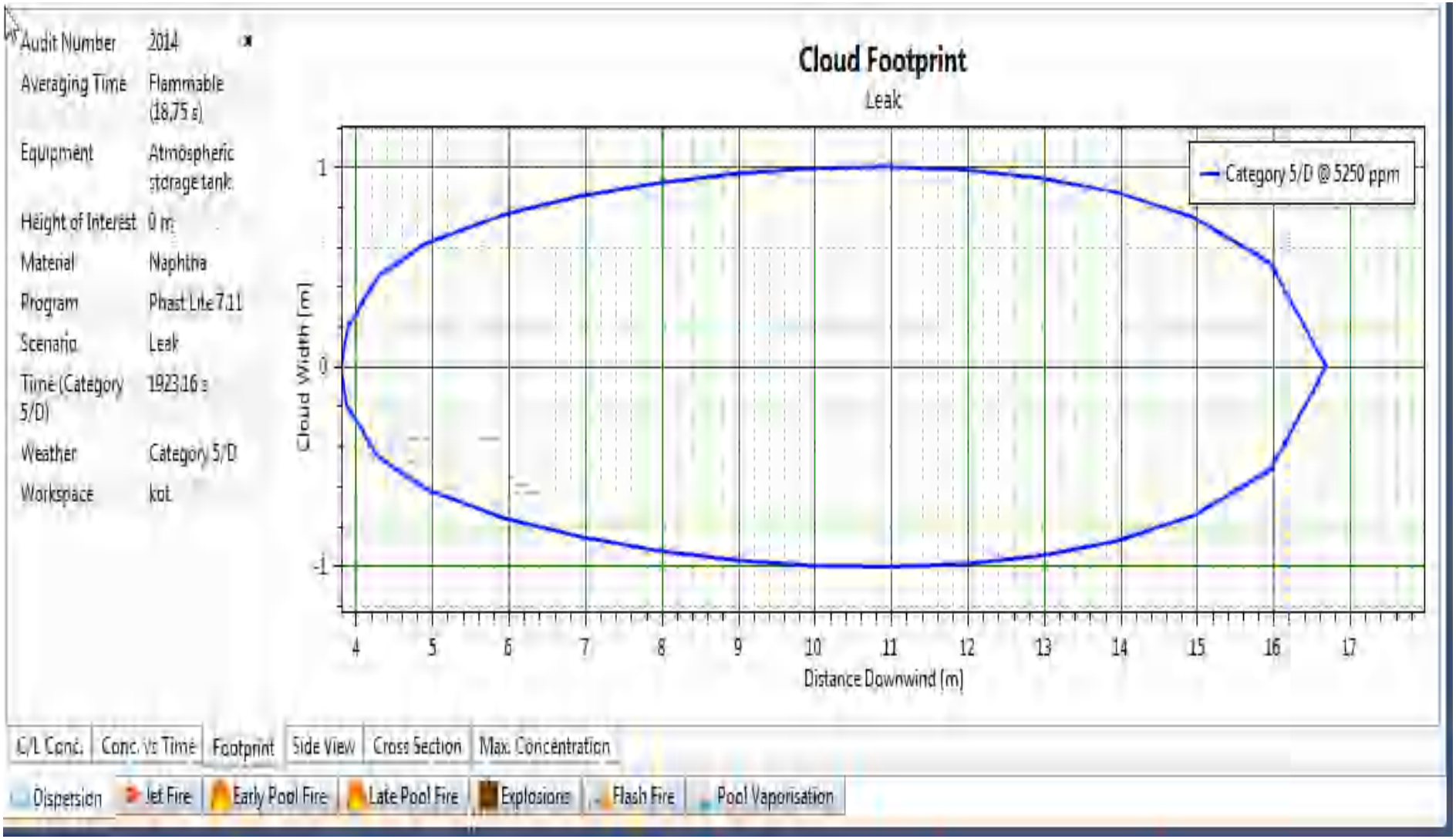


Figure 69:- Graph showing leak of Cloud Footprint from LBT of Kot station.

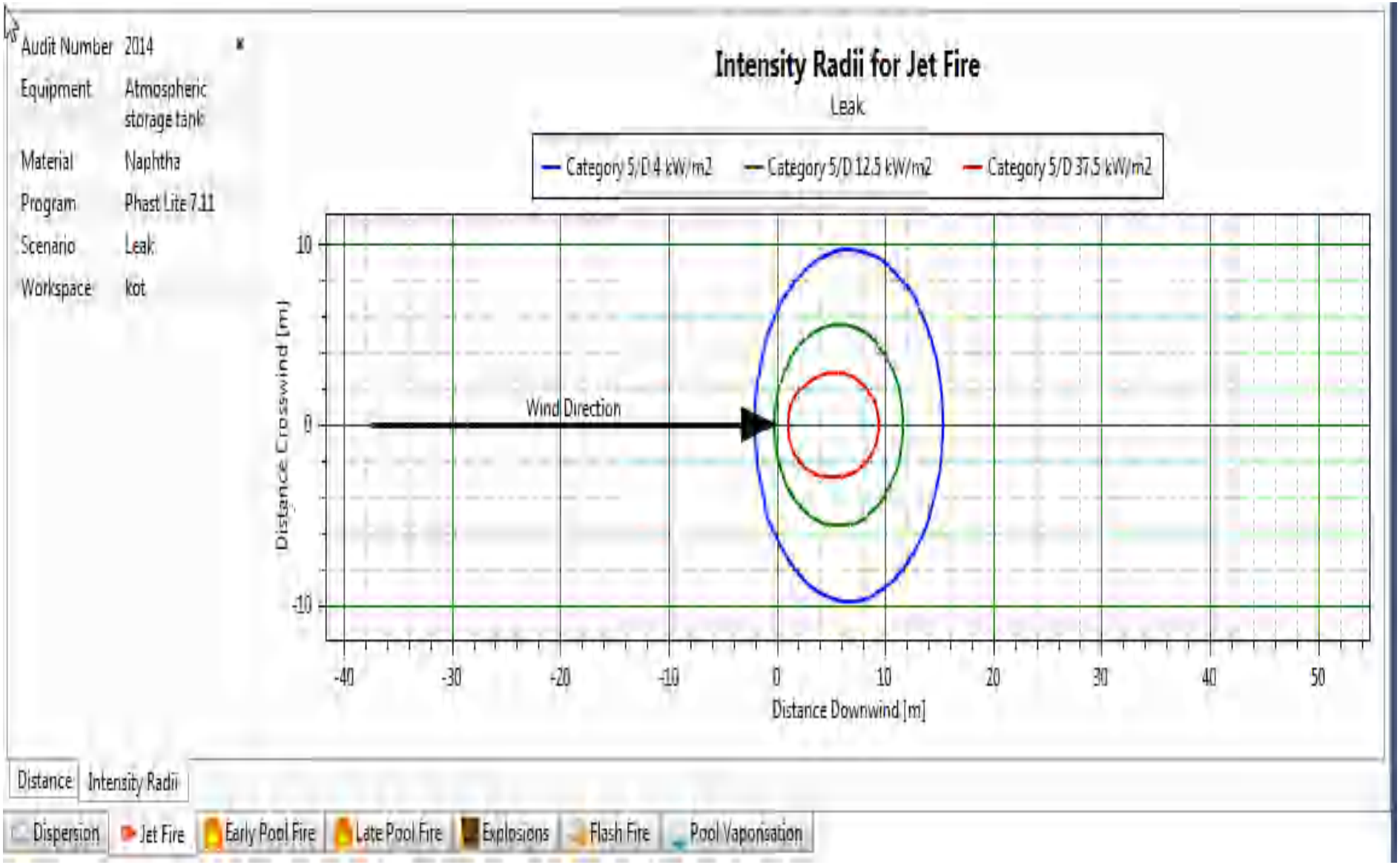


Figure 70:- Graph showing leak of Intensity Radii for Jet Fire from LBT of Kot station.

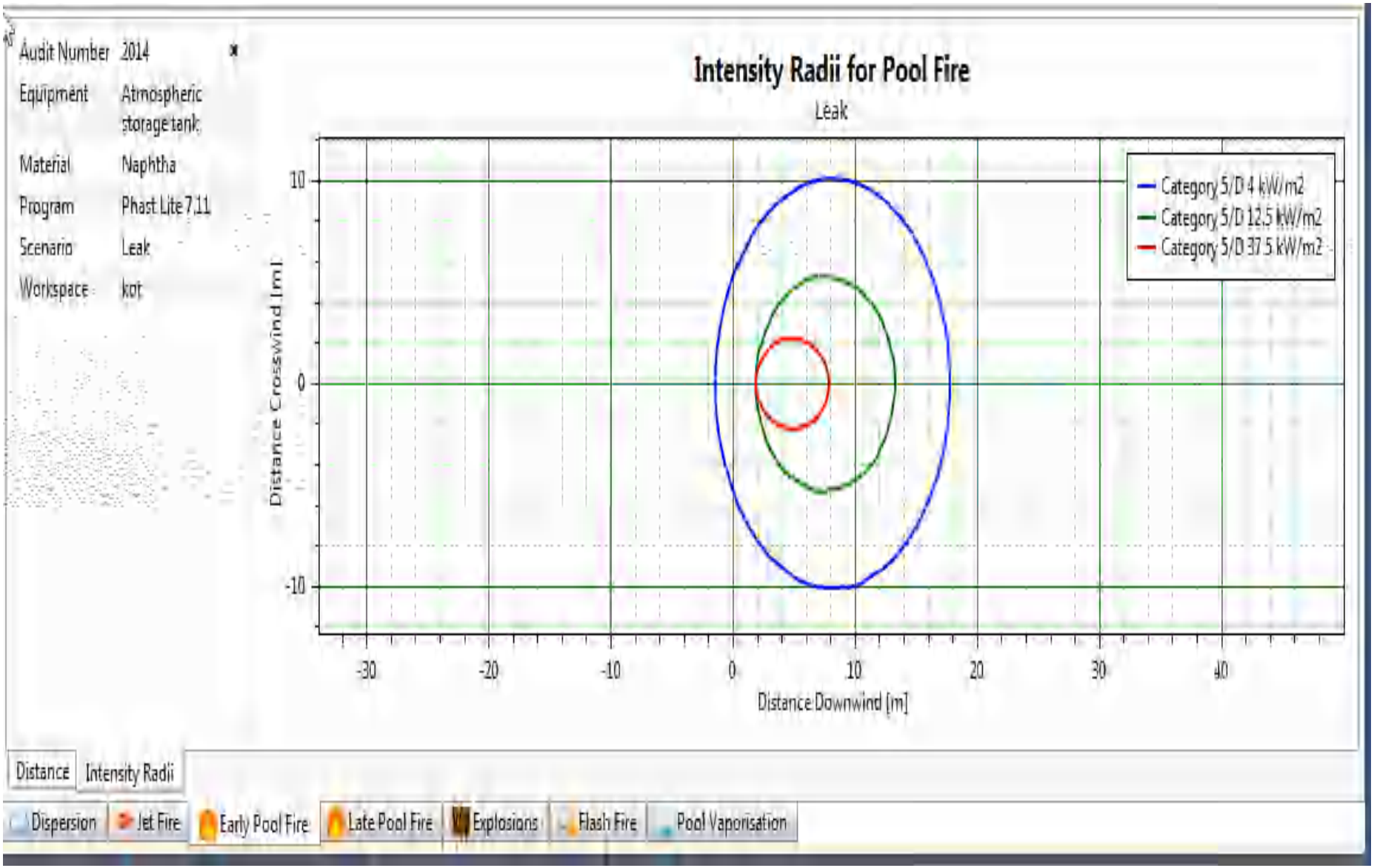


Figure 71:- Graph showing leak of Intensity Radii for Pool fire from LBT of Kot station.

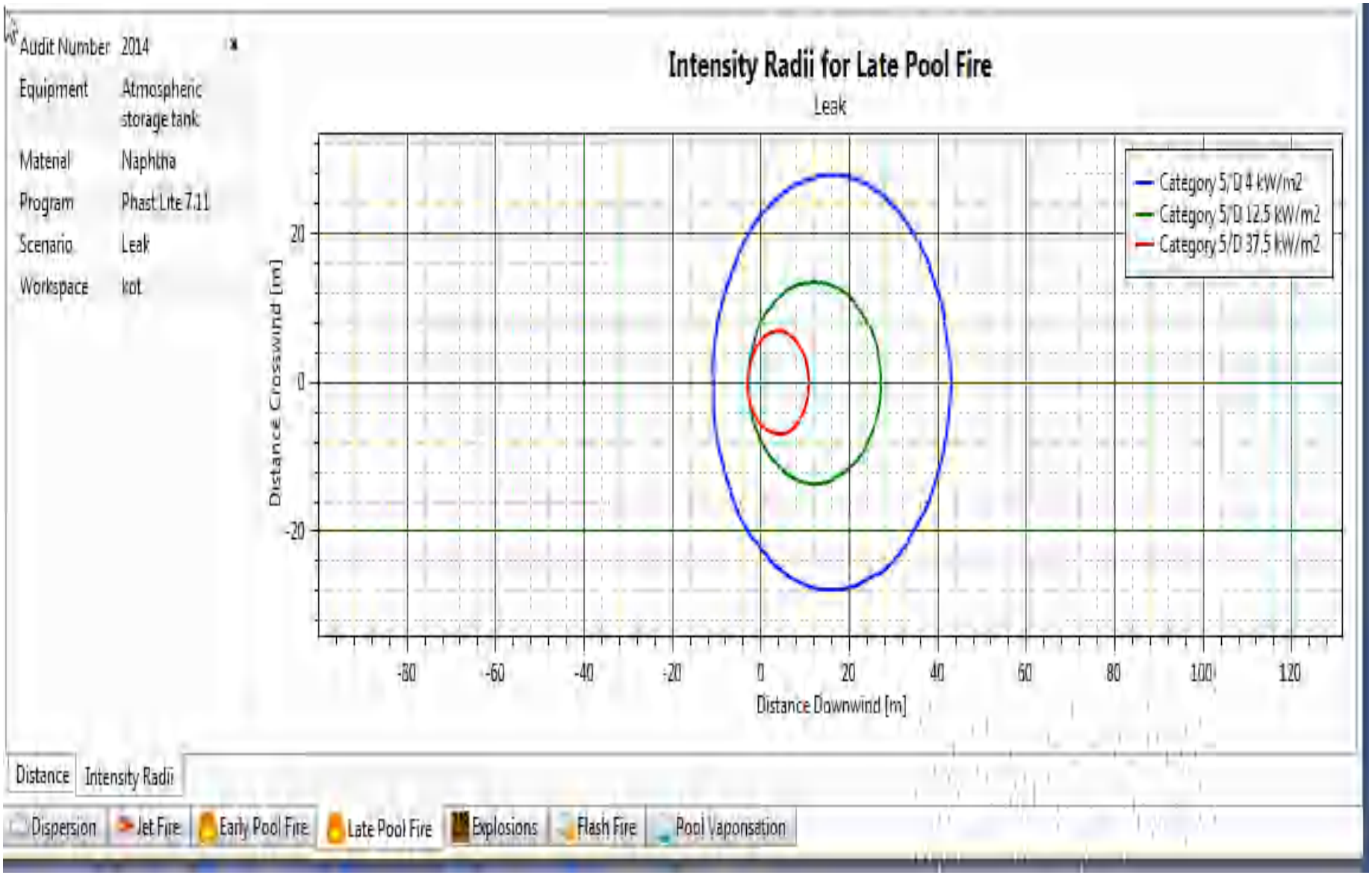


Figure 72:- Graph showing leak of Intensity radii for late pool fire from LBT of Kot station.

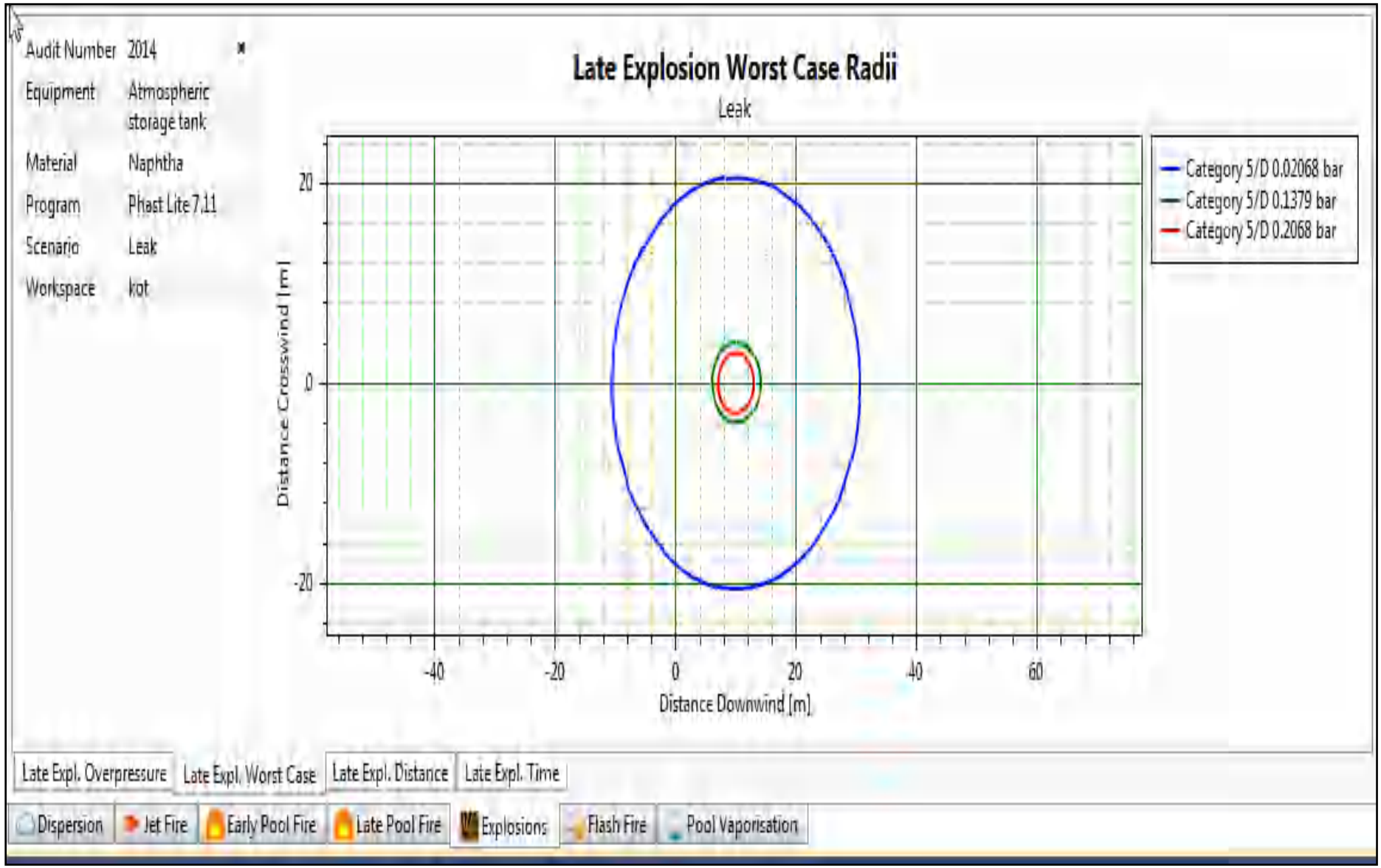


Figure 73:- Graph showing leak of Late Explosion Worst Case Radii from LBT of Kot station.

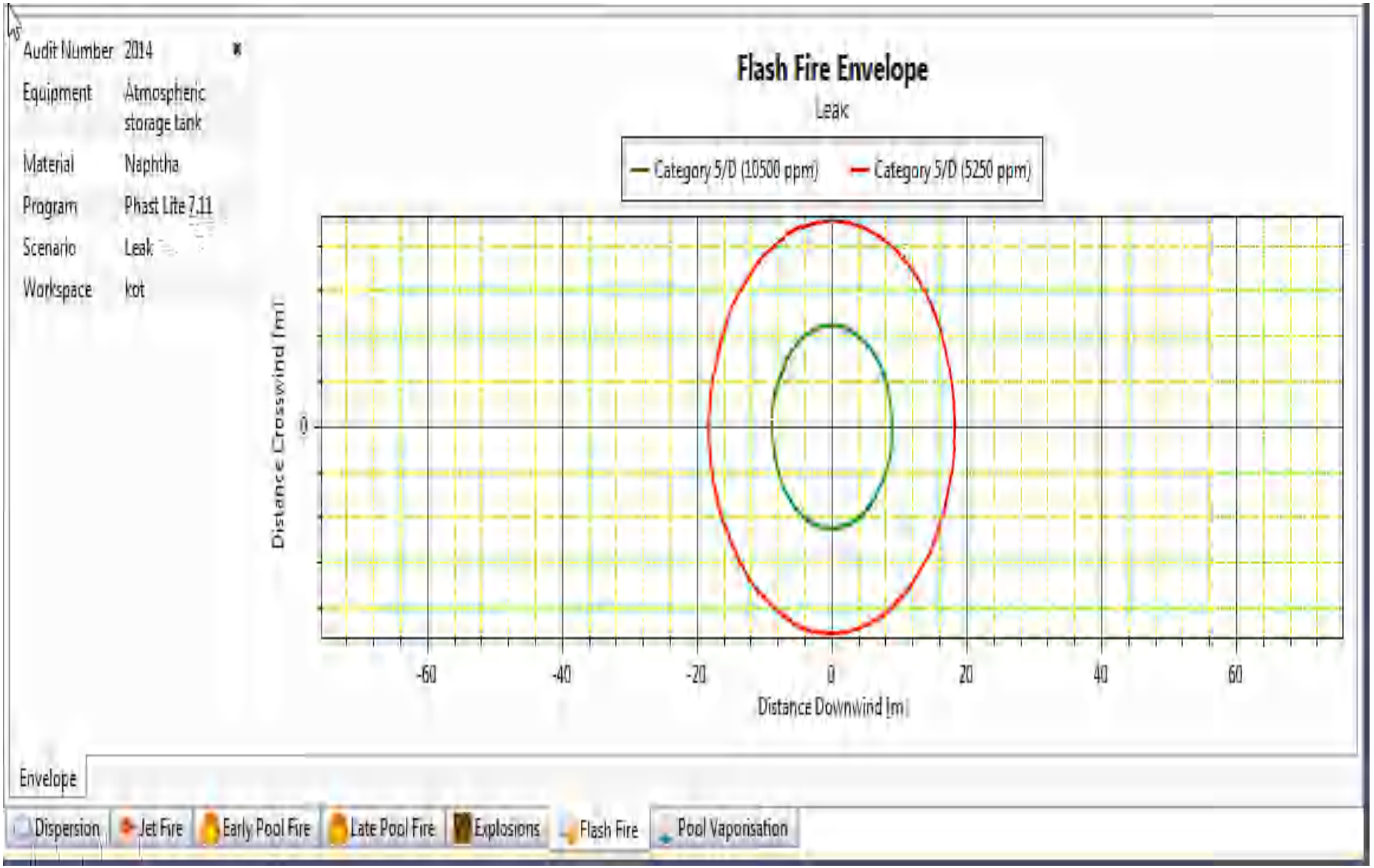


Figure 74:- Graph showing leak of Flash Fire Envelope from LBT of Kot station.

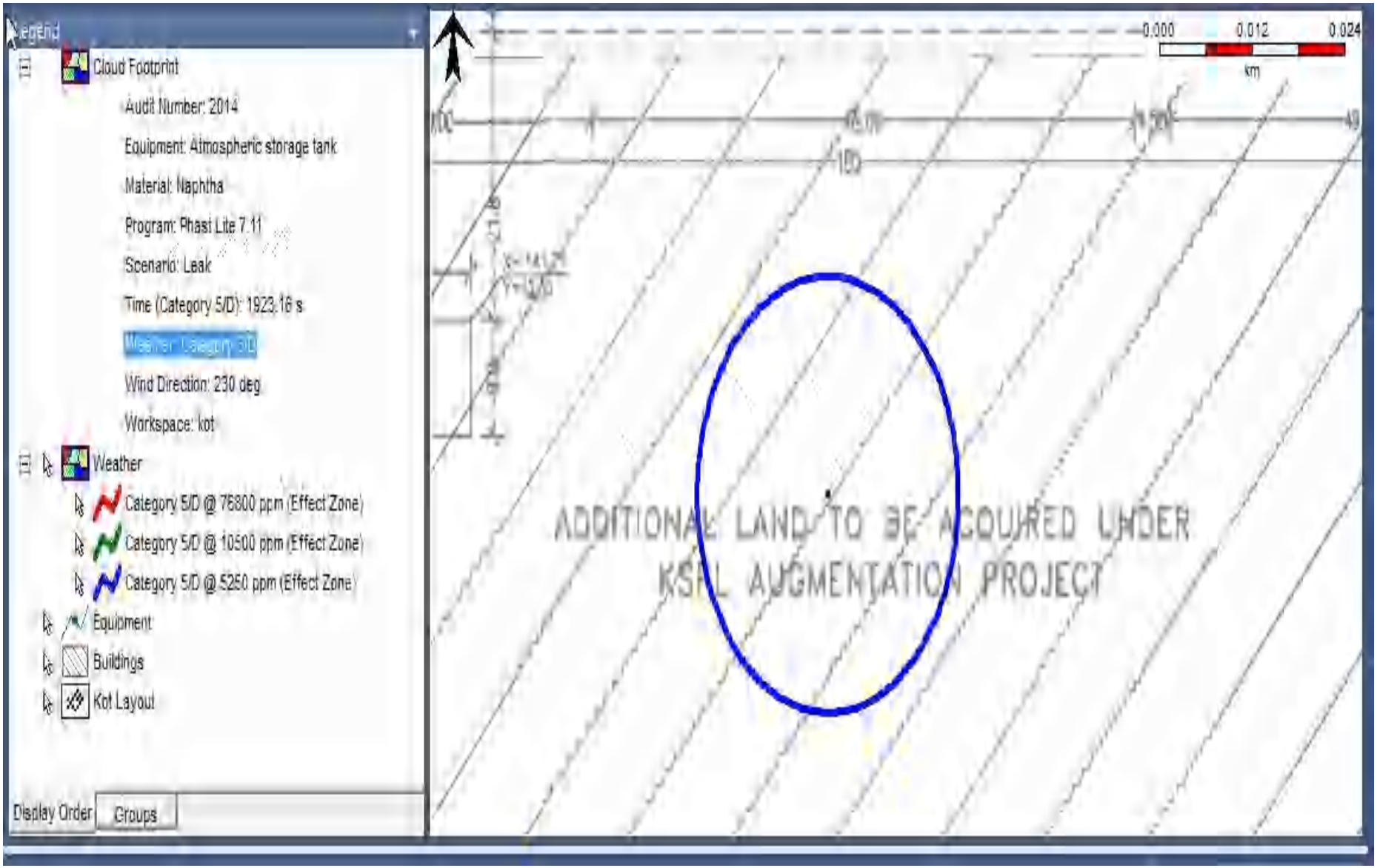


Figure 75:- Cloud Footprint of Kot station (Leak of LBT)

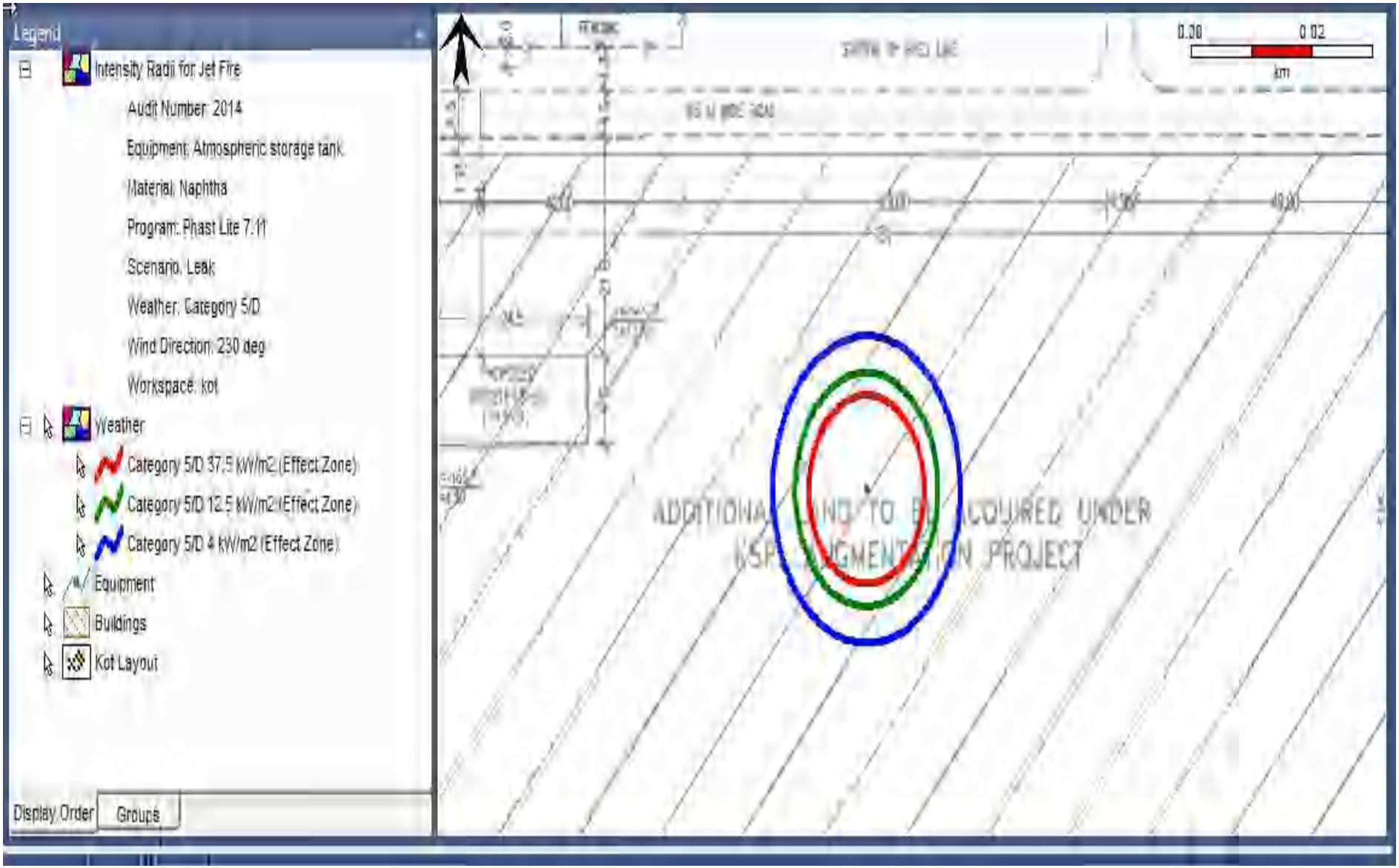


Figure 76:- Intensity Radii for Jet Fire of Kot station (Leak of LBT)

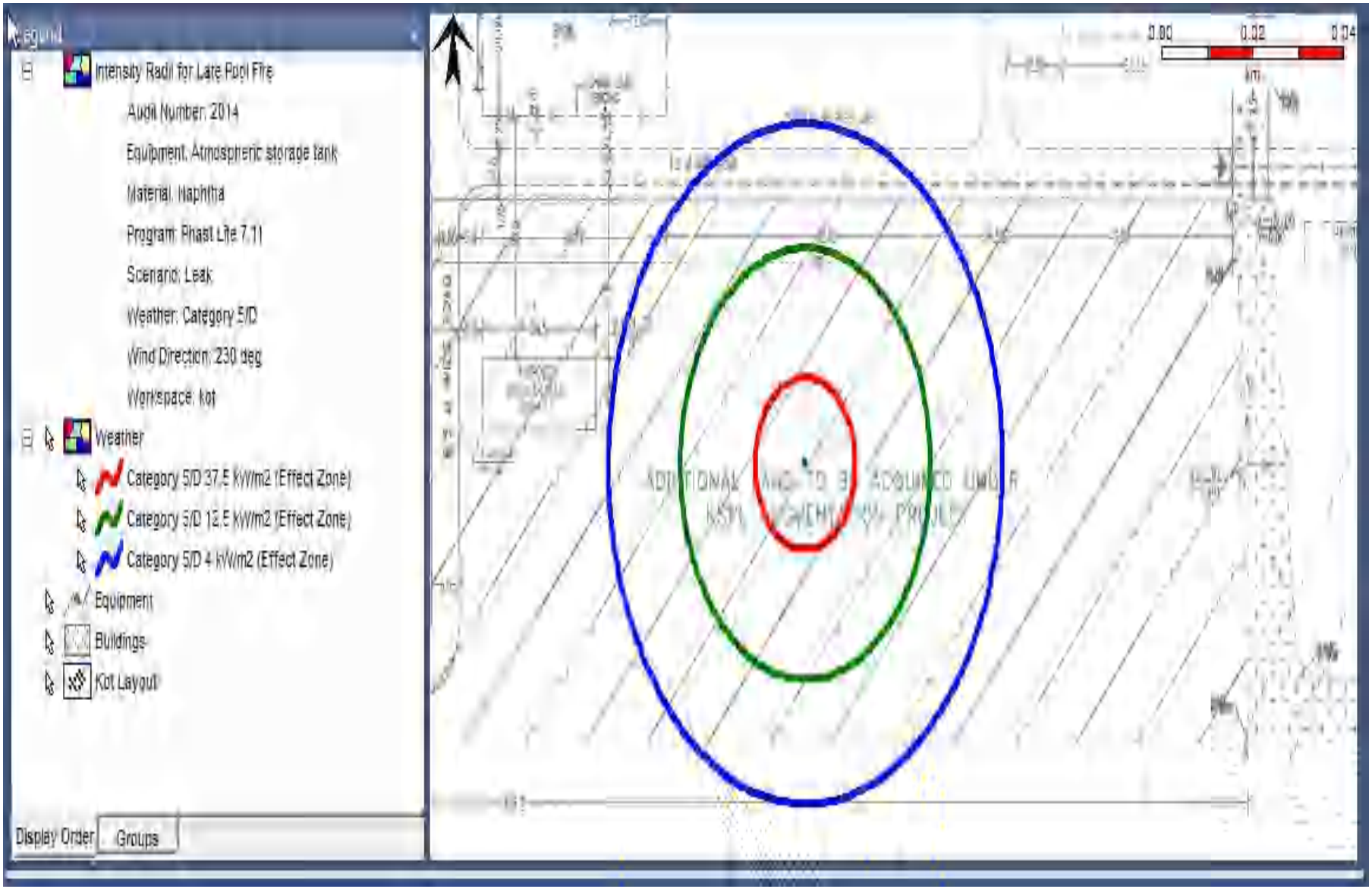


Figure 77:- Intensity Radii for Late Pool Fire of Kot station (Leak of LBT)

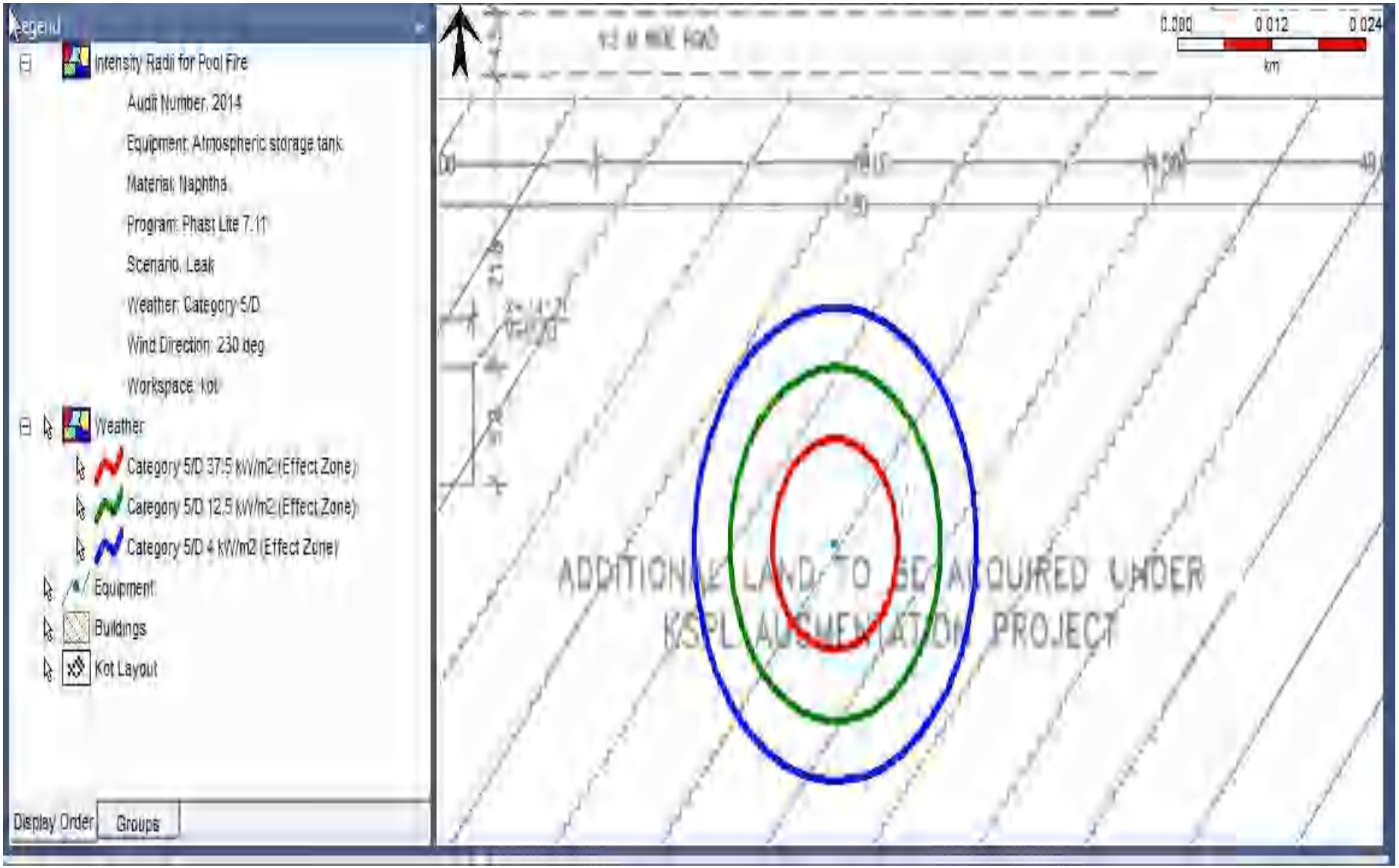


Figure 78:- Intensity Radii for Pool Fire of Kot station (Leak of LBT)

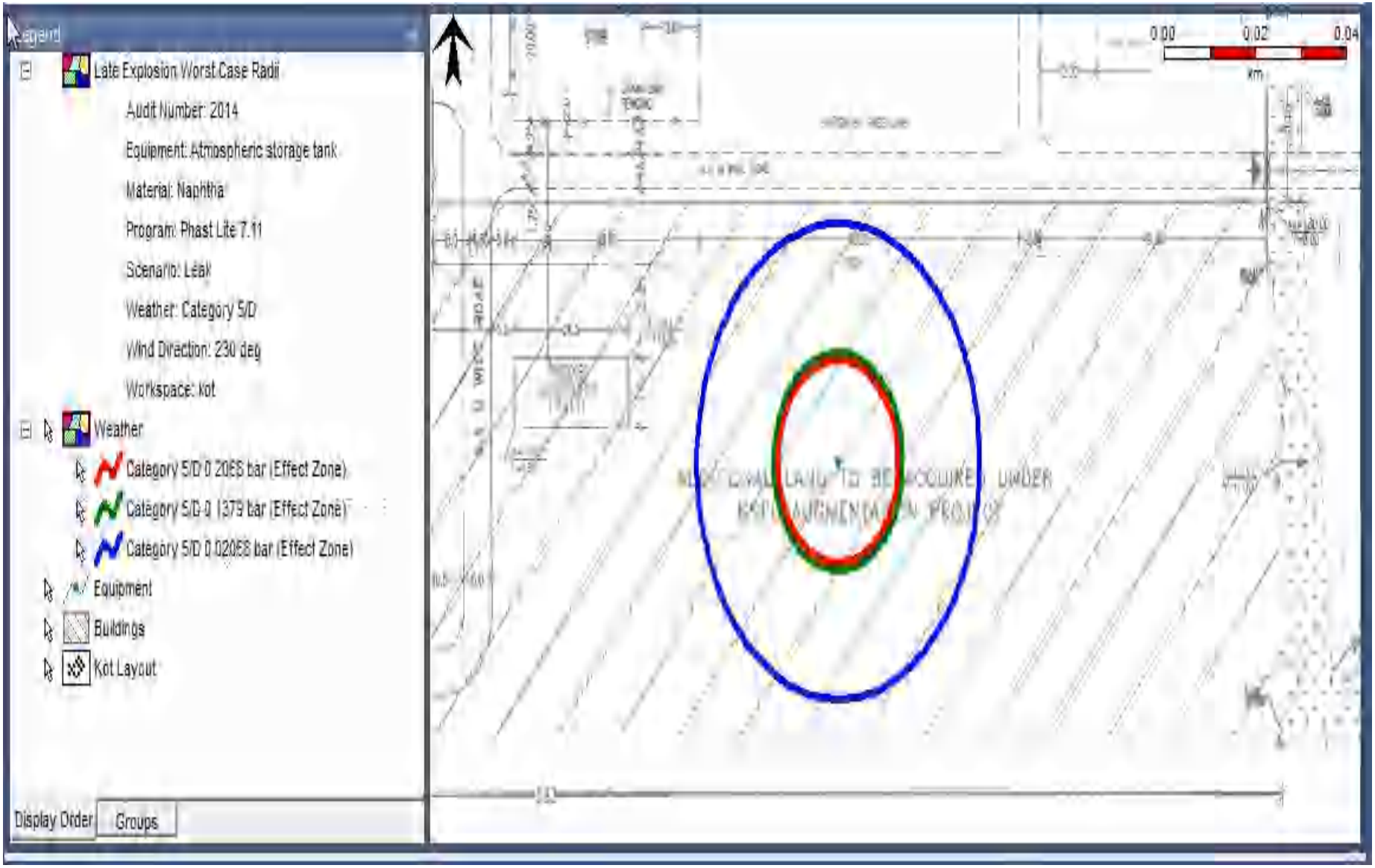


Figure 79: Late Explosion Worst Case Radii of Kot station (Leak of LBT)

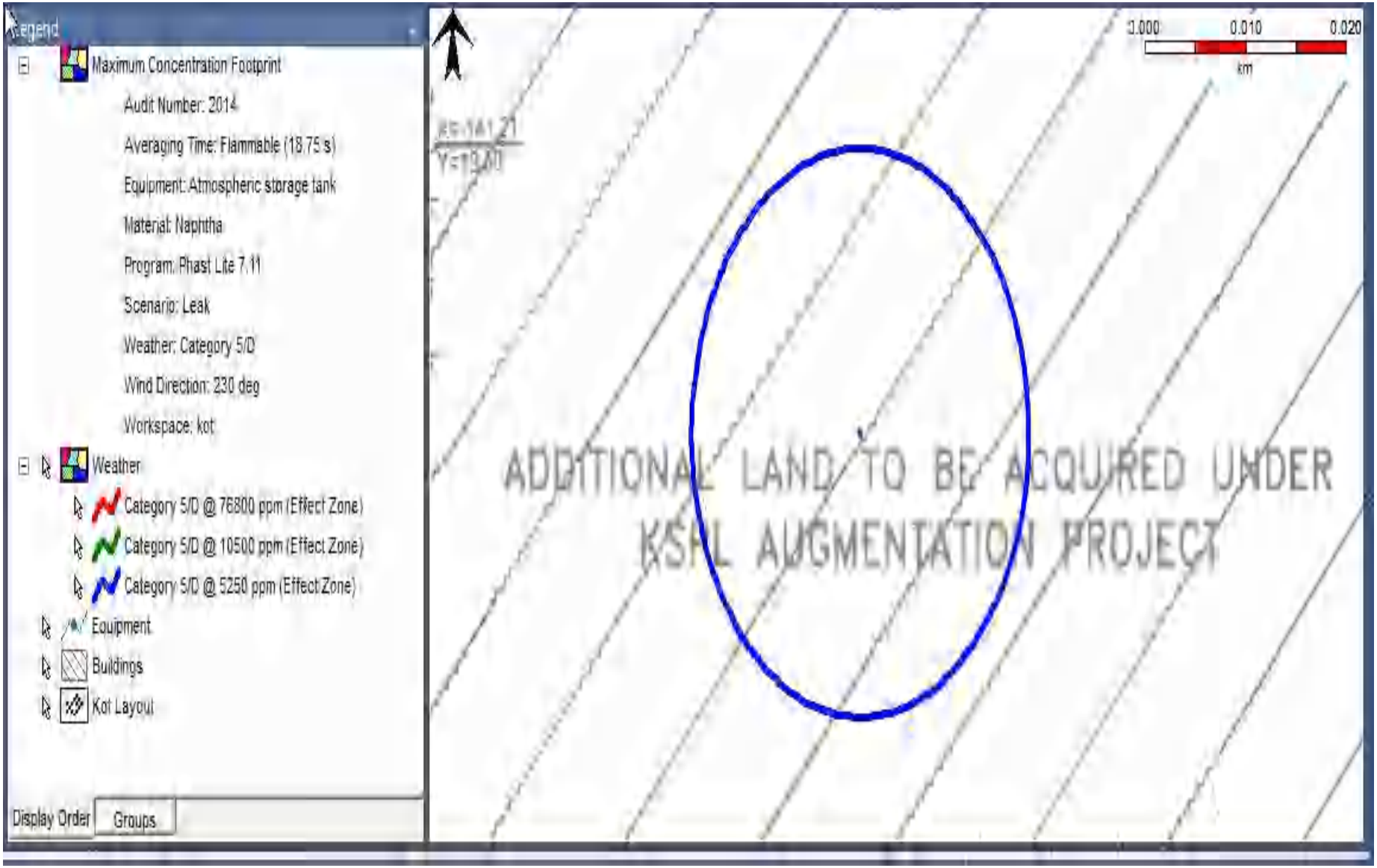


Figure 80:- Maximum Concentration Footprint of Kot station (Leak of pipeline)

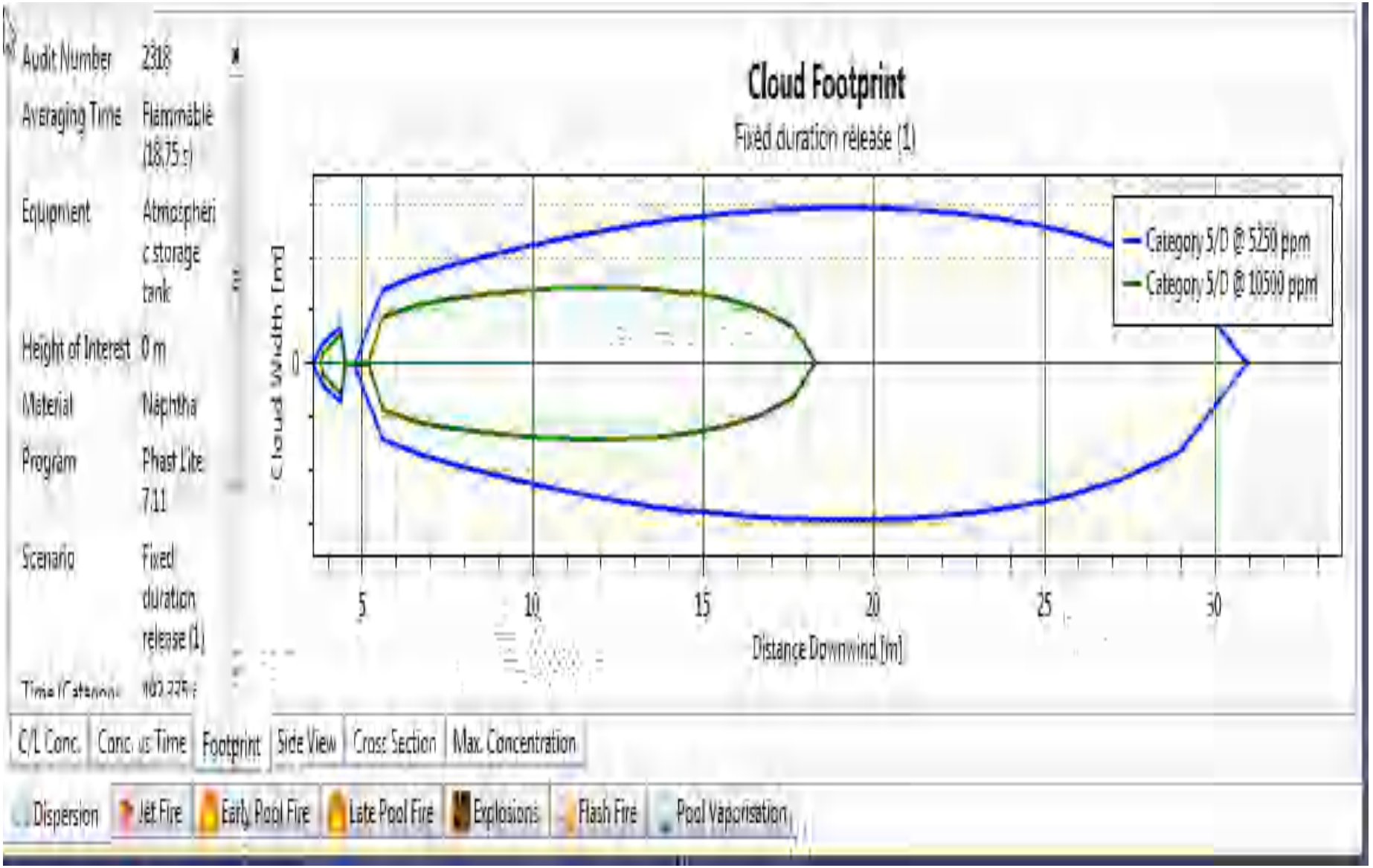


Figure 81:- Graph showing rupture of Cloud footprint from LBT of Kot station.

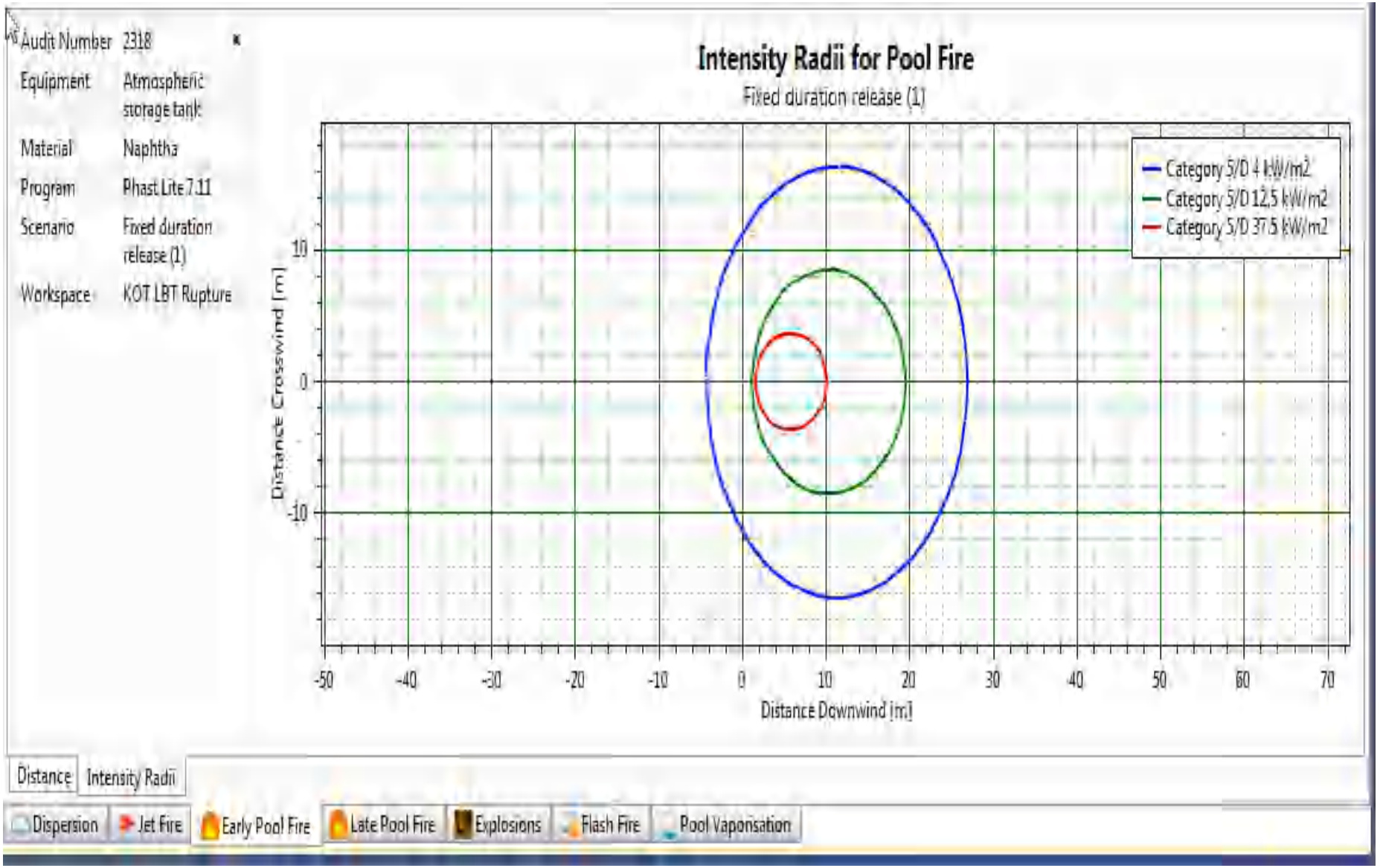


Figure 82:- Graph showing rupture of Intensity Radii for Pool Fire from LBT of Kot station.

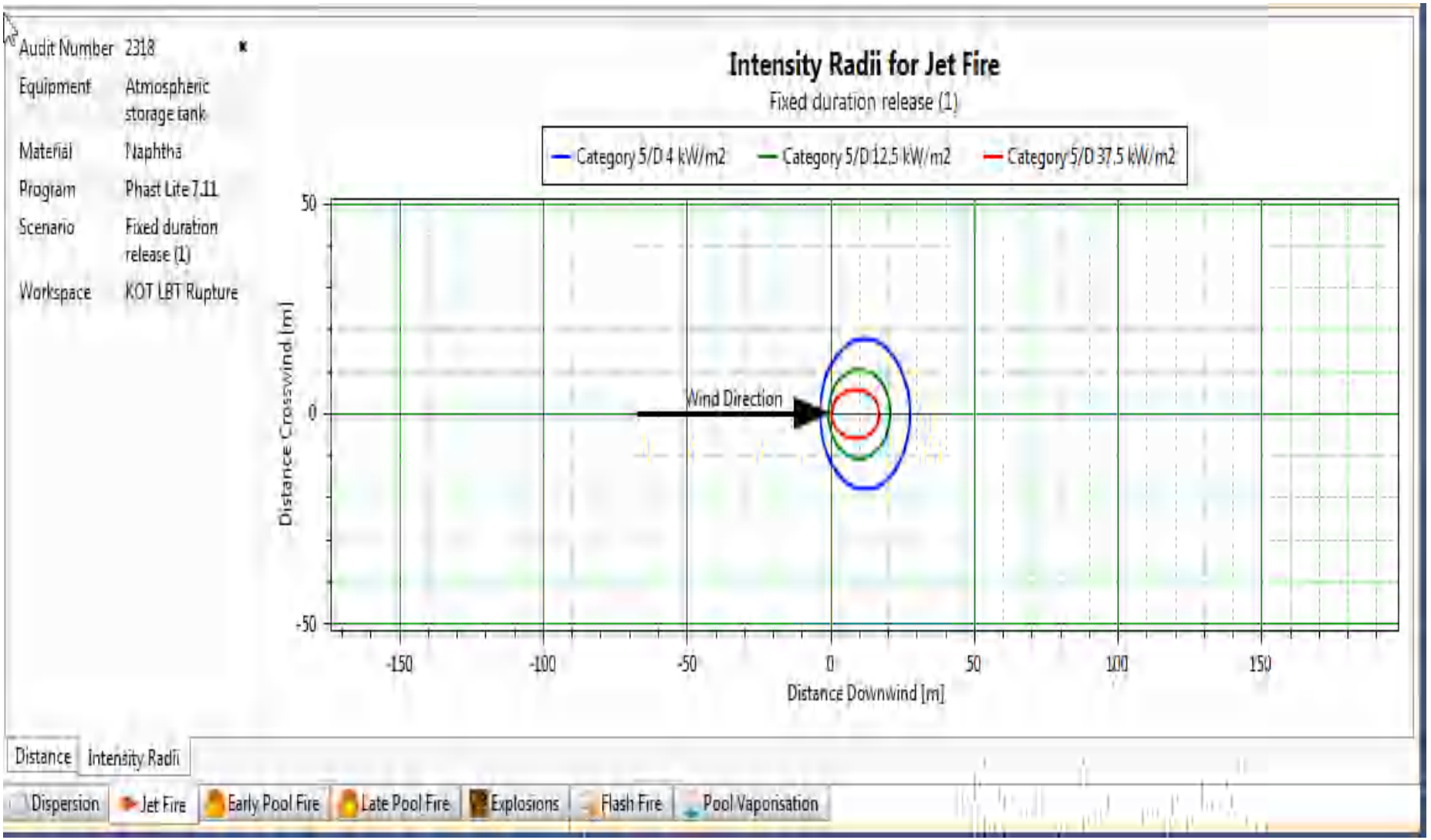


Figure 83:- Graph showing rupture of Intensity Radii for Jet Fire from LBT of Kot station.

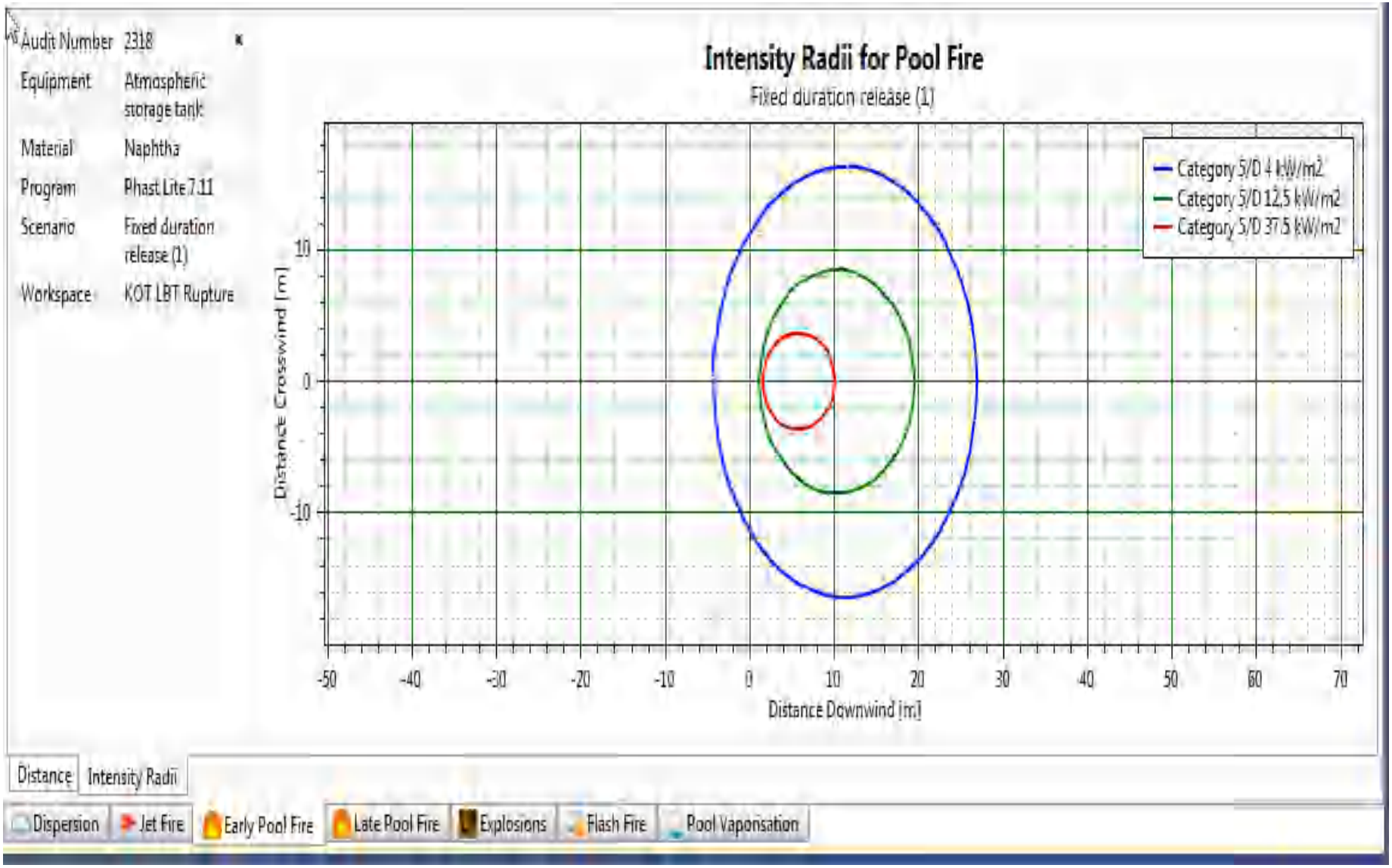


Figure 84:- Graph showing rupture of Intensity Radii Pool Fire from LBT of Kot station.

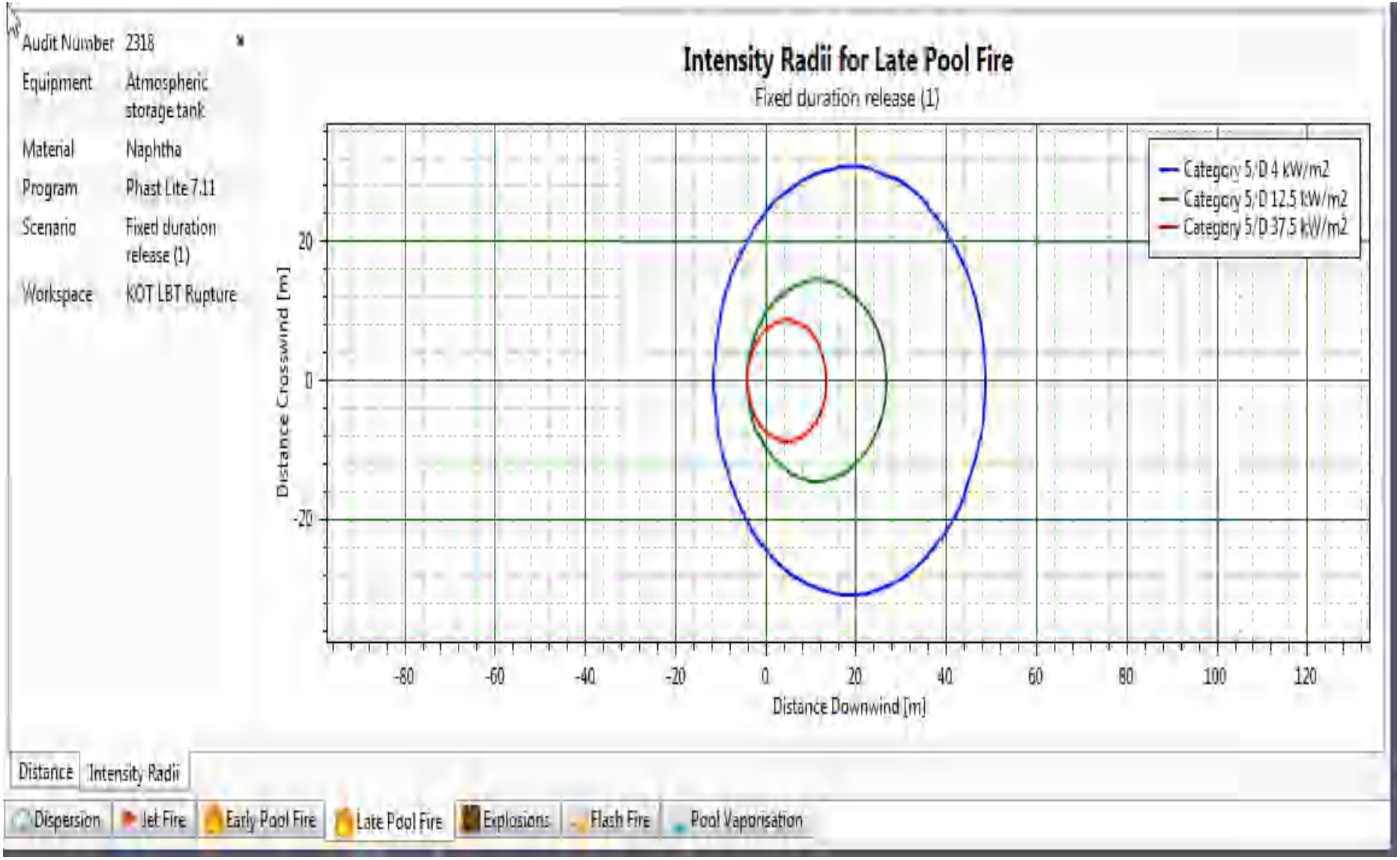


Figure 85:- Graph showing rupture of Intensity radii for late pool fire from LBT of Kot station.

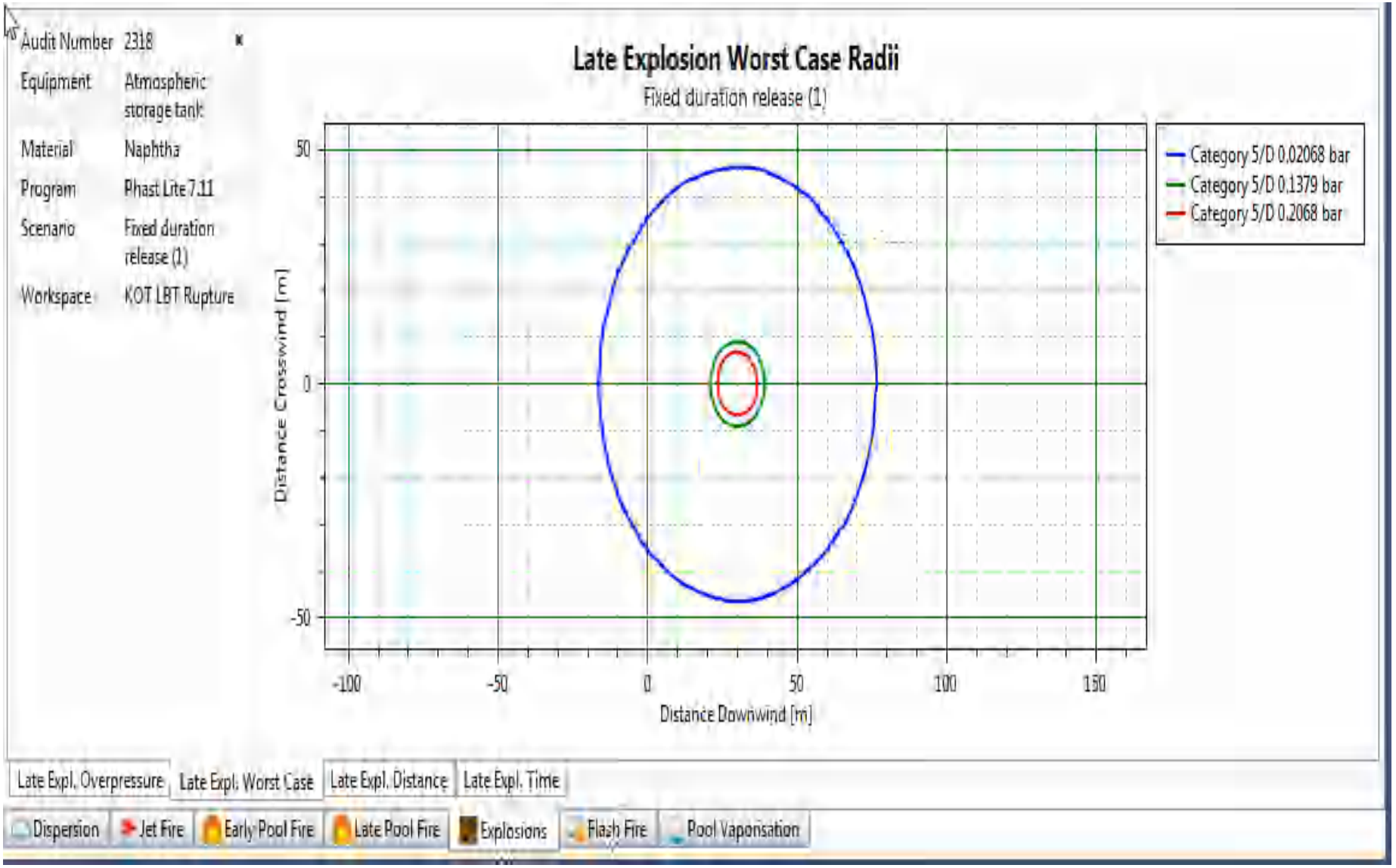


Figure 86:- Graph showing rupture of Late Explosion Worst Case Radii from LBT of Kot station.

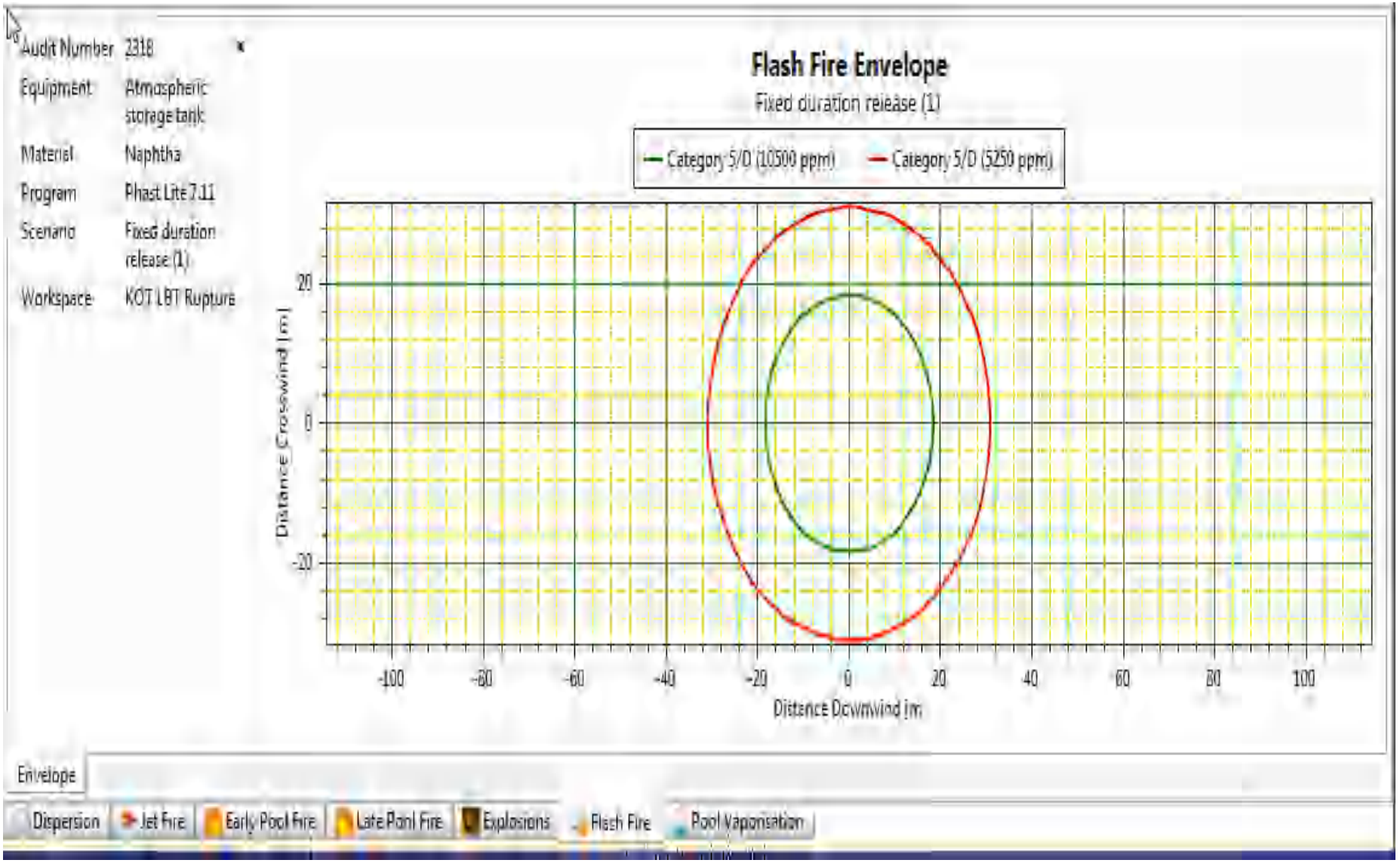


Figure 87:- Graph showing rupture of Flash Fire envelope from LBT of Kot station.

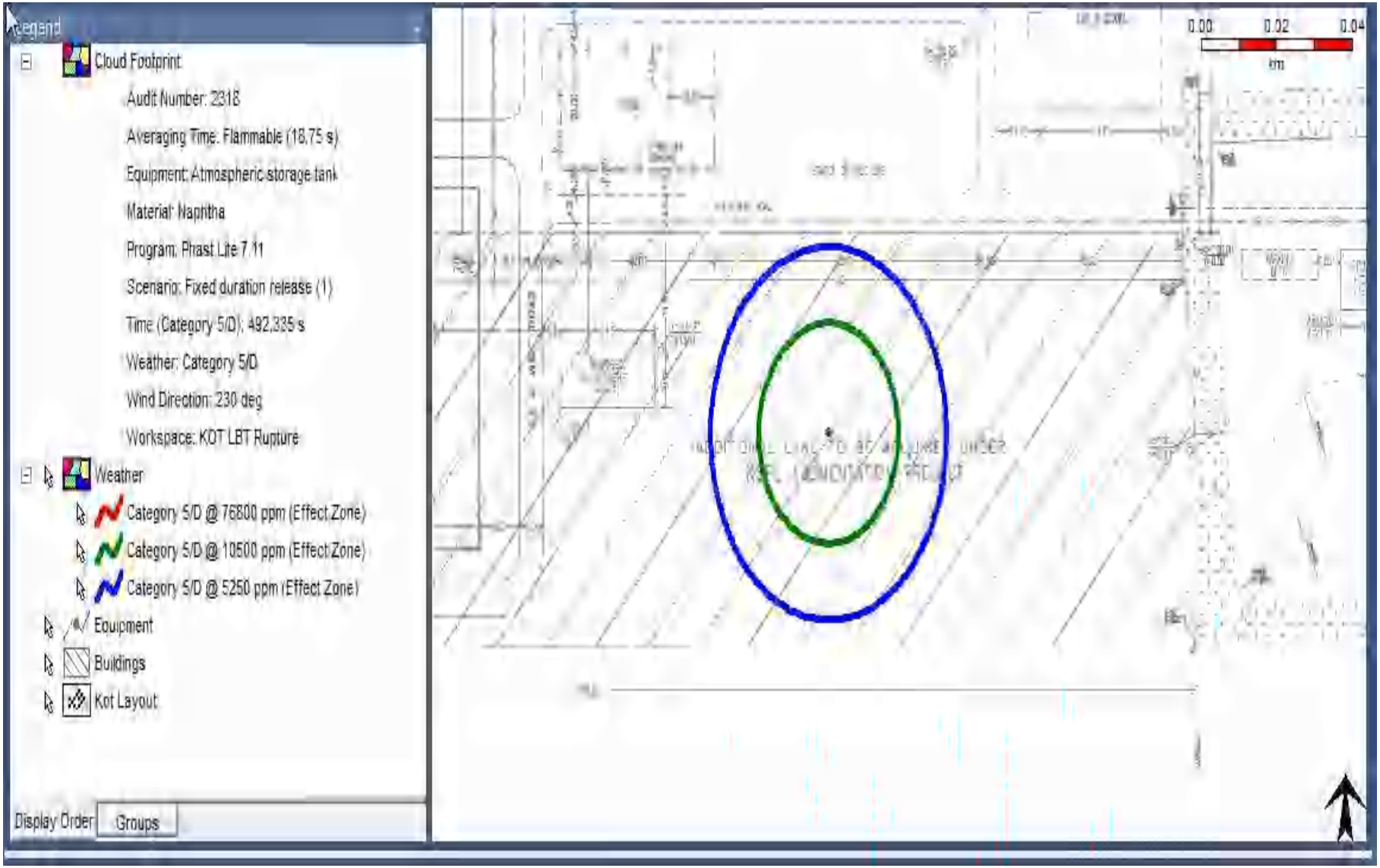


Figure 88:- Cloud Footprint of Kot station (Rupture of LBT)

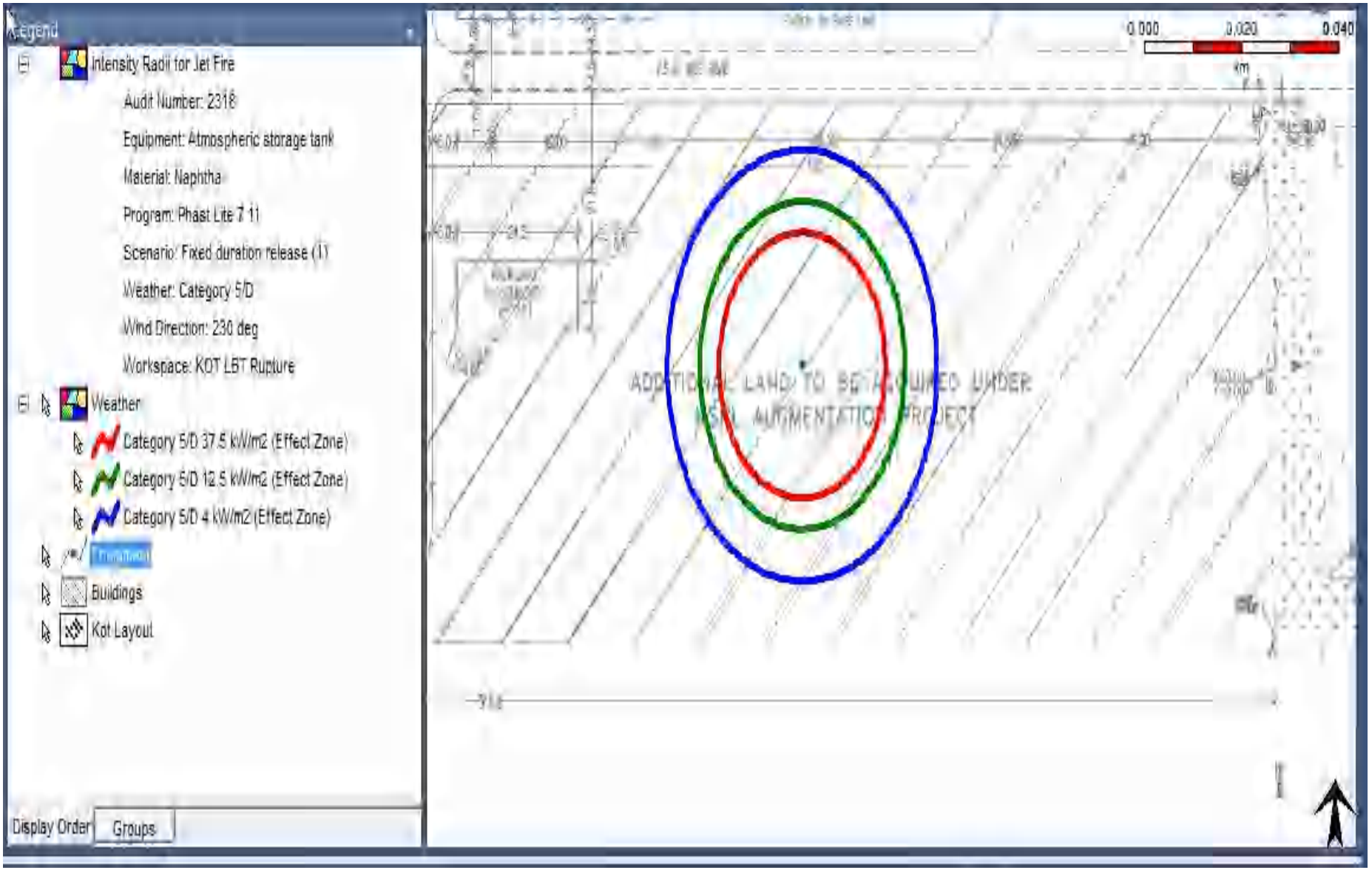


Figure 89:- Intensity Radii for Jet Fire of Kot station (Rupture of LBT)

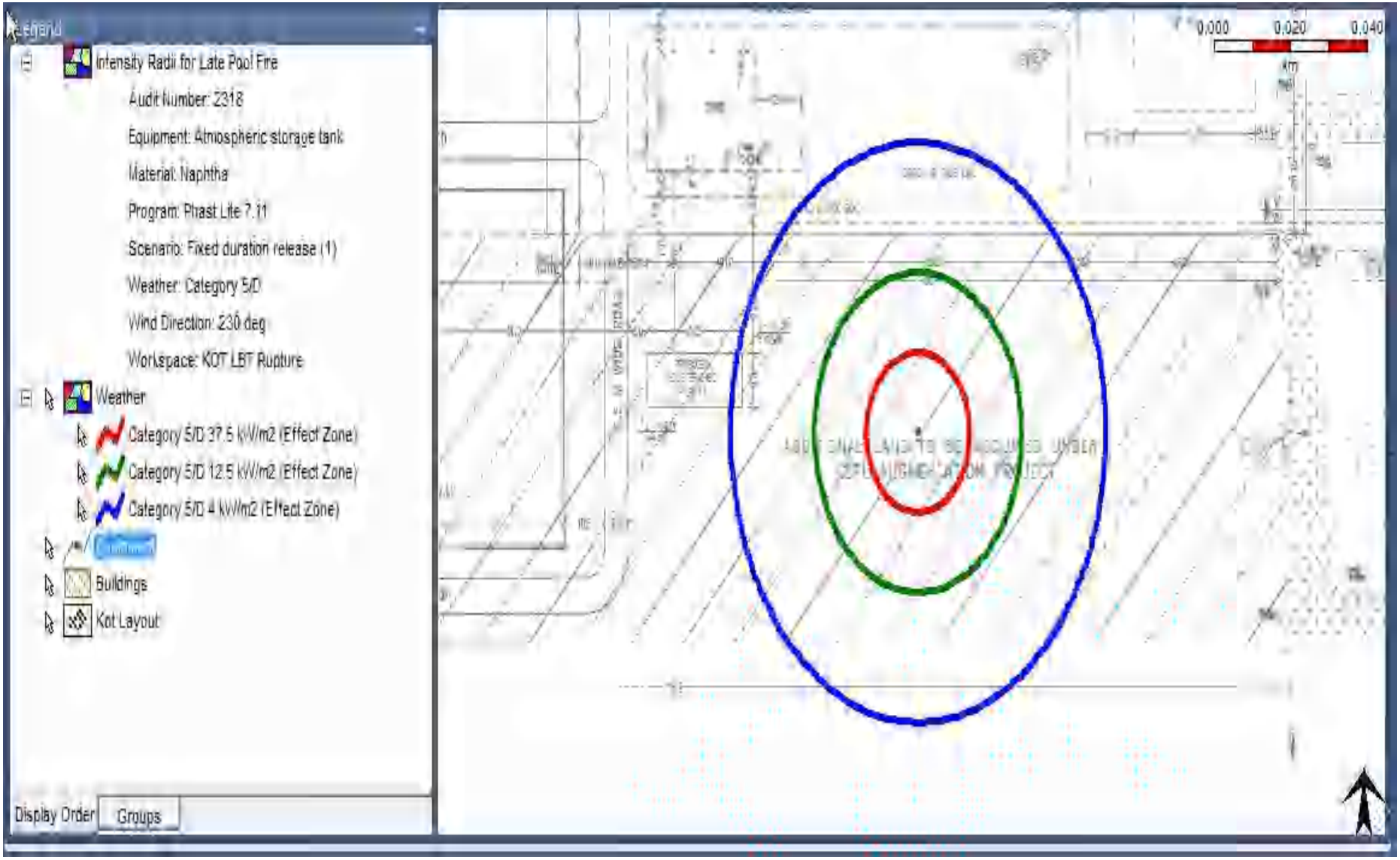


Figure 90:- Intensity Radii for Late Pool Fire of Kot station (Rupture of LBT)

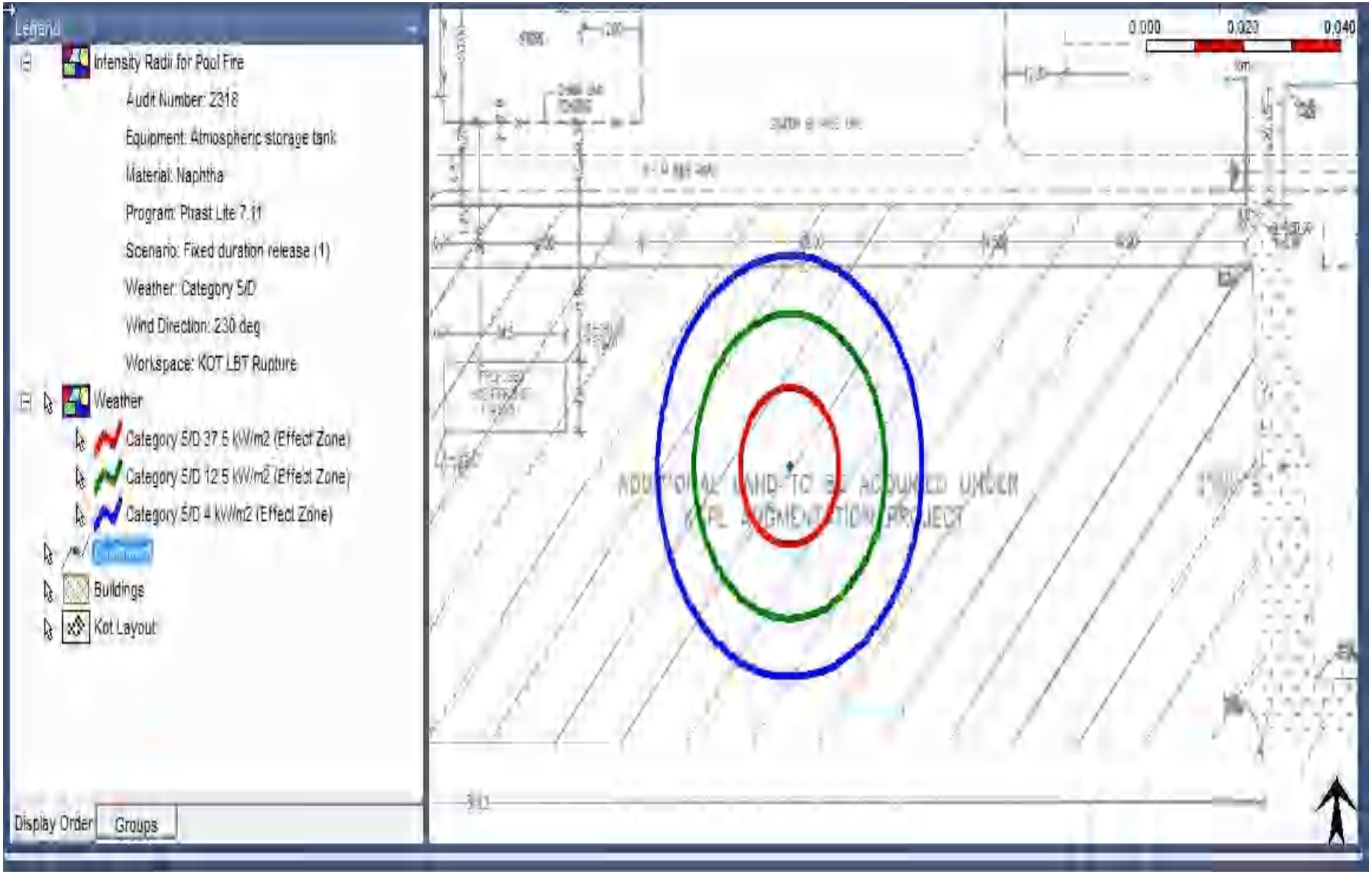


Figure 91:- Intensity Radii for Pool Fire of Kot station (Rupture of LBT)

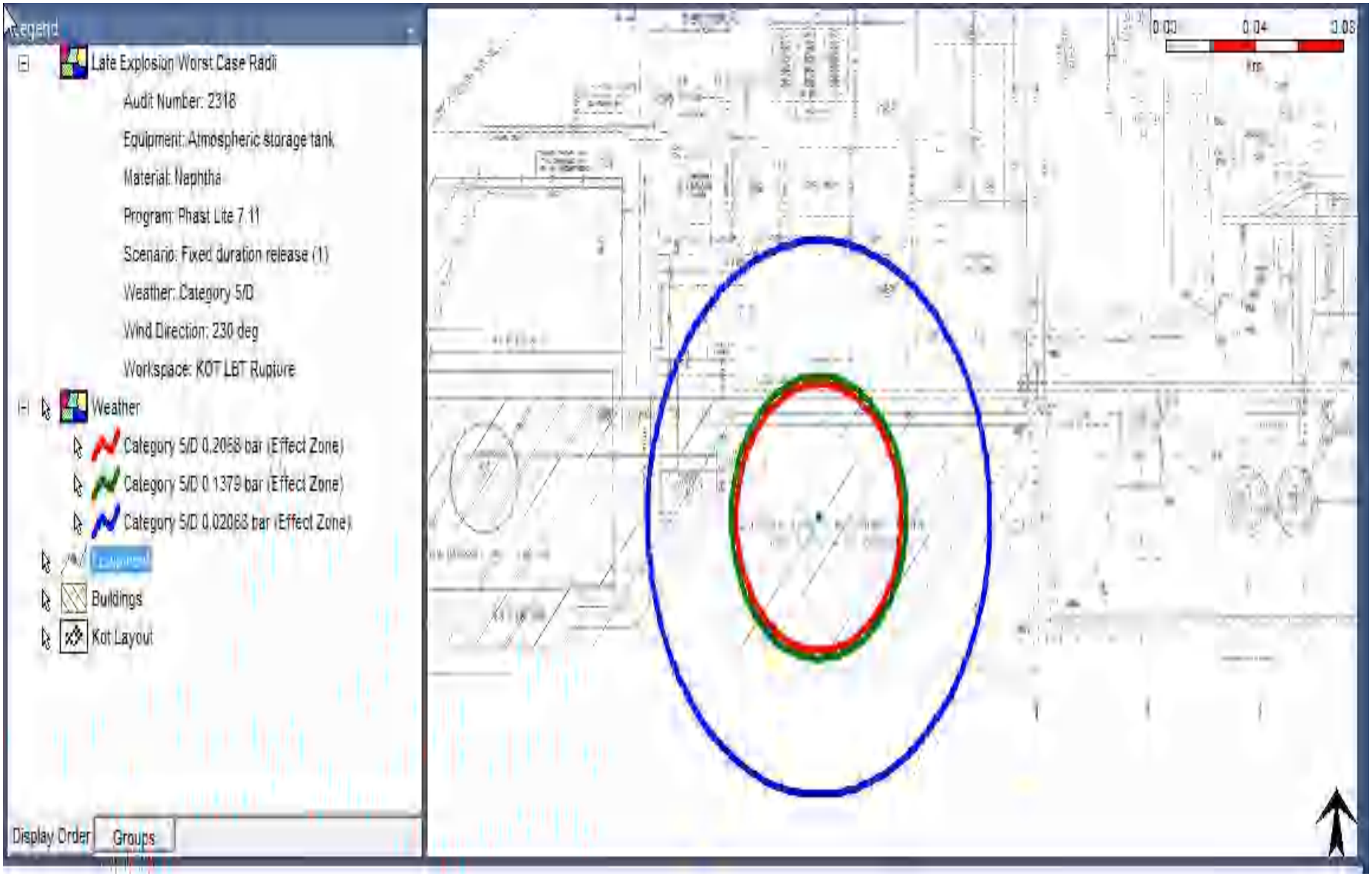


Figure 92:- :- Late Explosion Worst Case Radii of Kot station (Rupture of LBT)

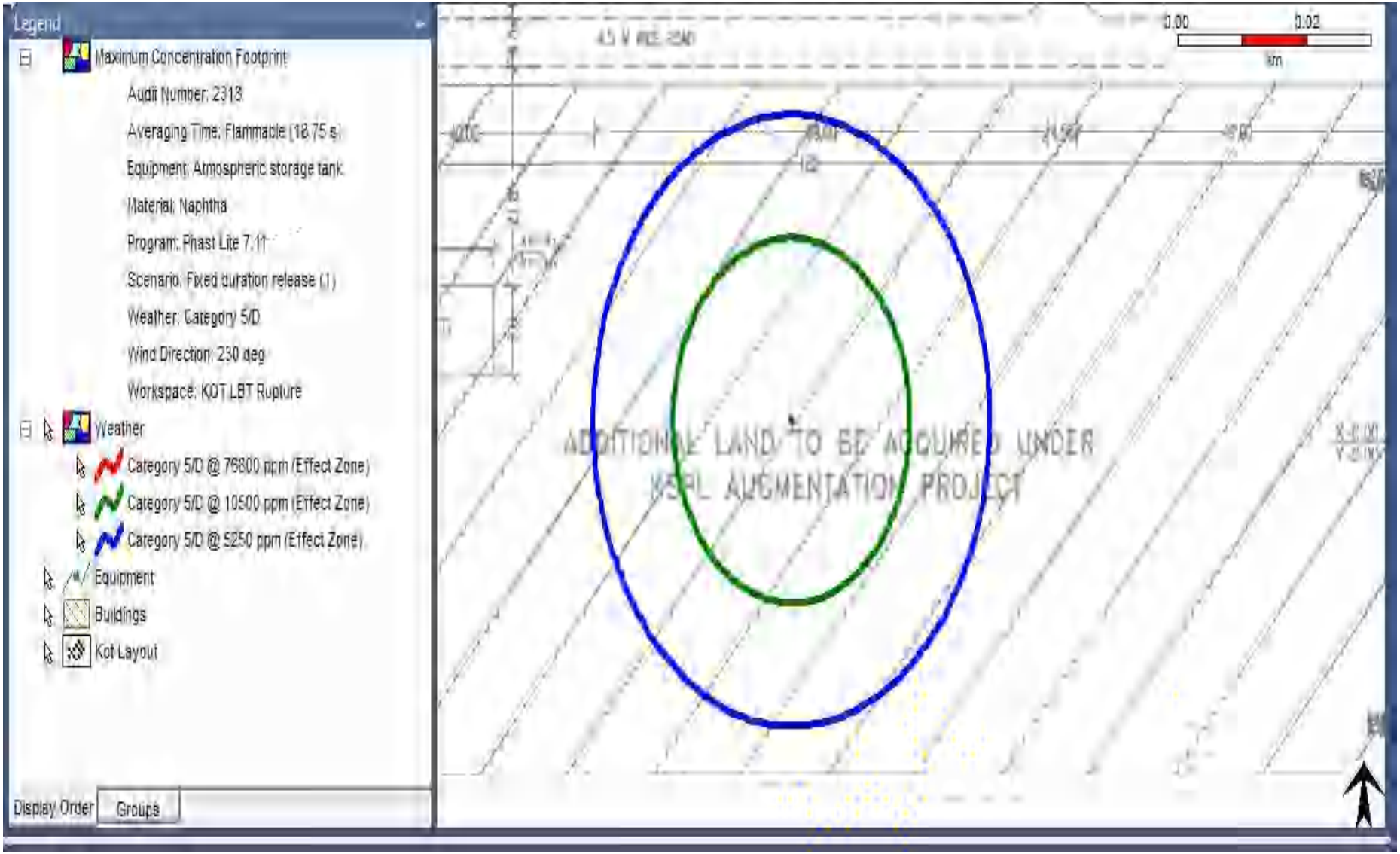


Figure 93:- Maximum Concentration Footprint of Kot station (Rupture of LBT)

VIRAMGAM

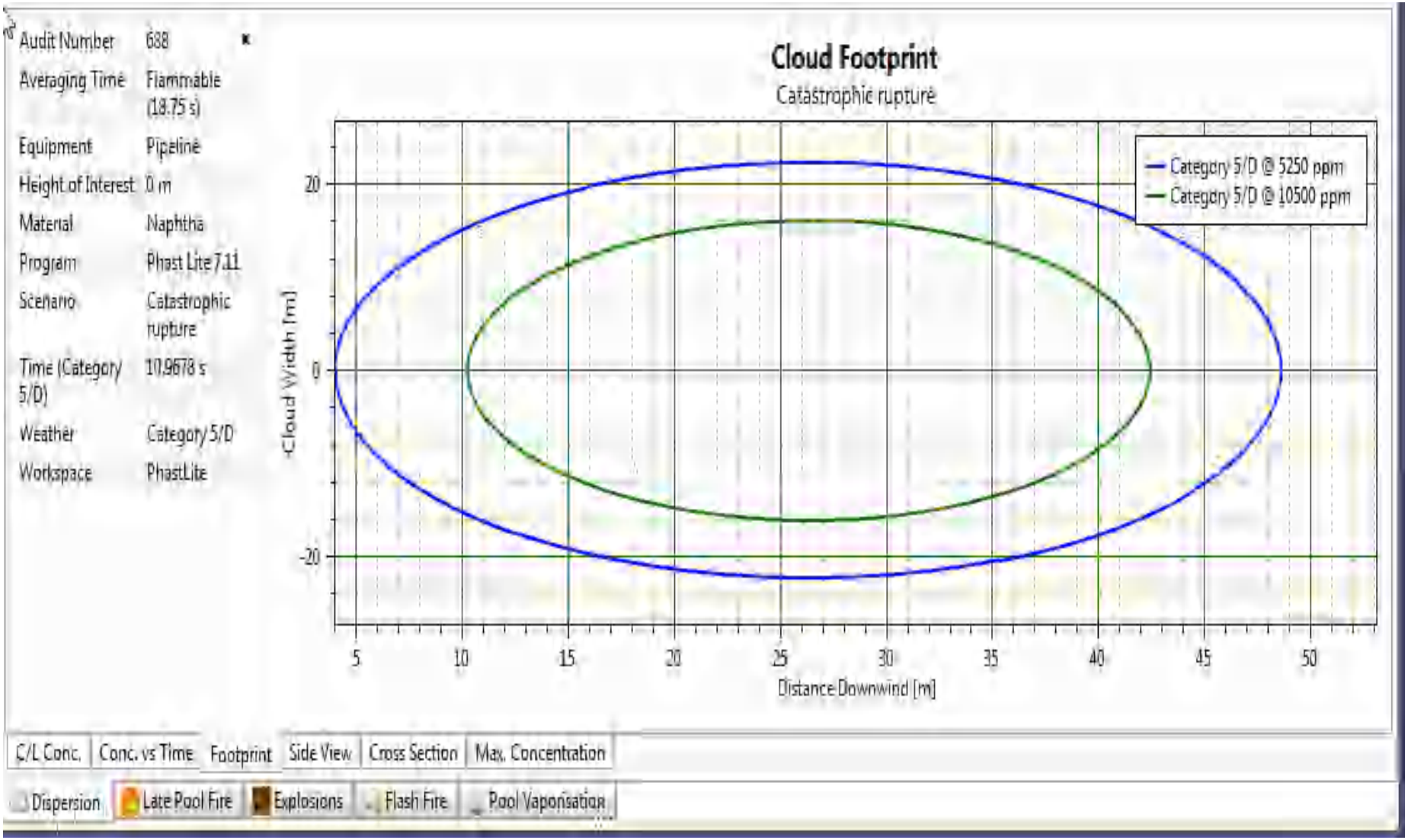


Figure 94:- Graph showing rupture of Cloud Footprint from pipeline of Viramgam station.

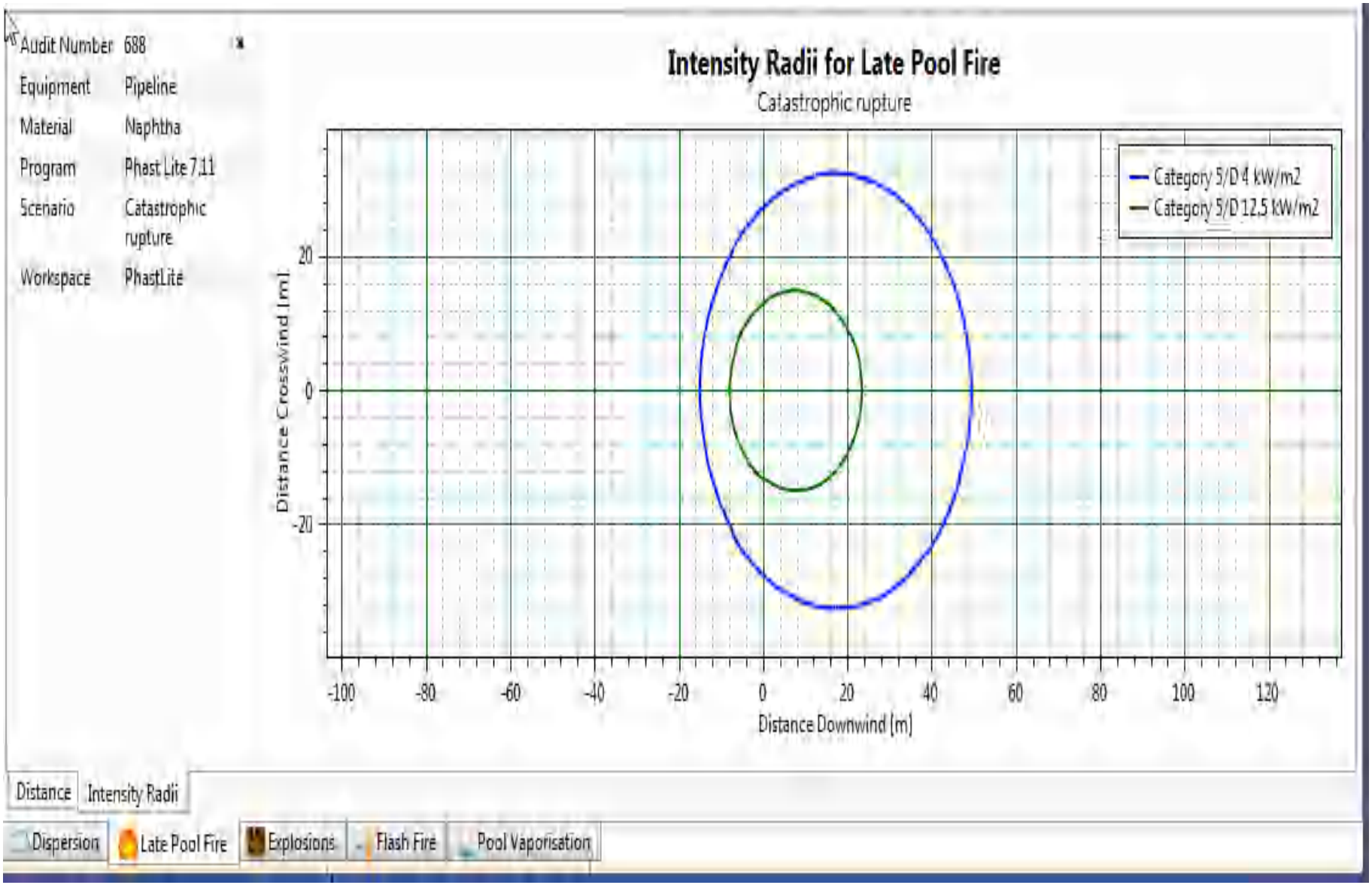


Figure 95:- Rupture graph of Intensity Radii for Late Pool Fire from pipeline of Viramgam station.

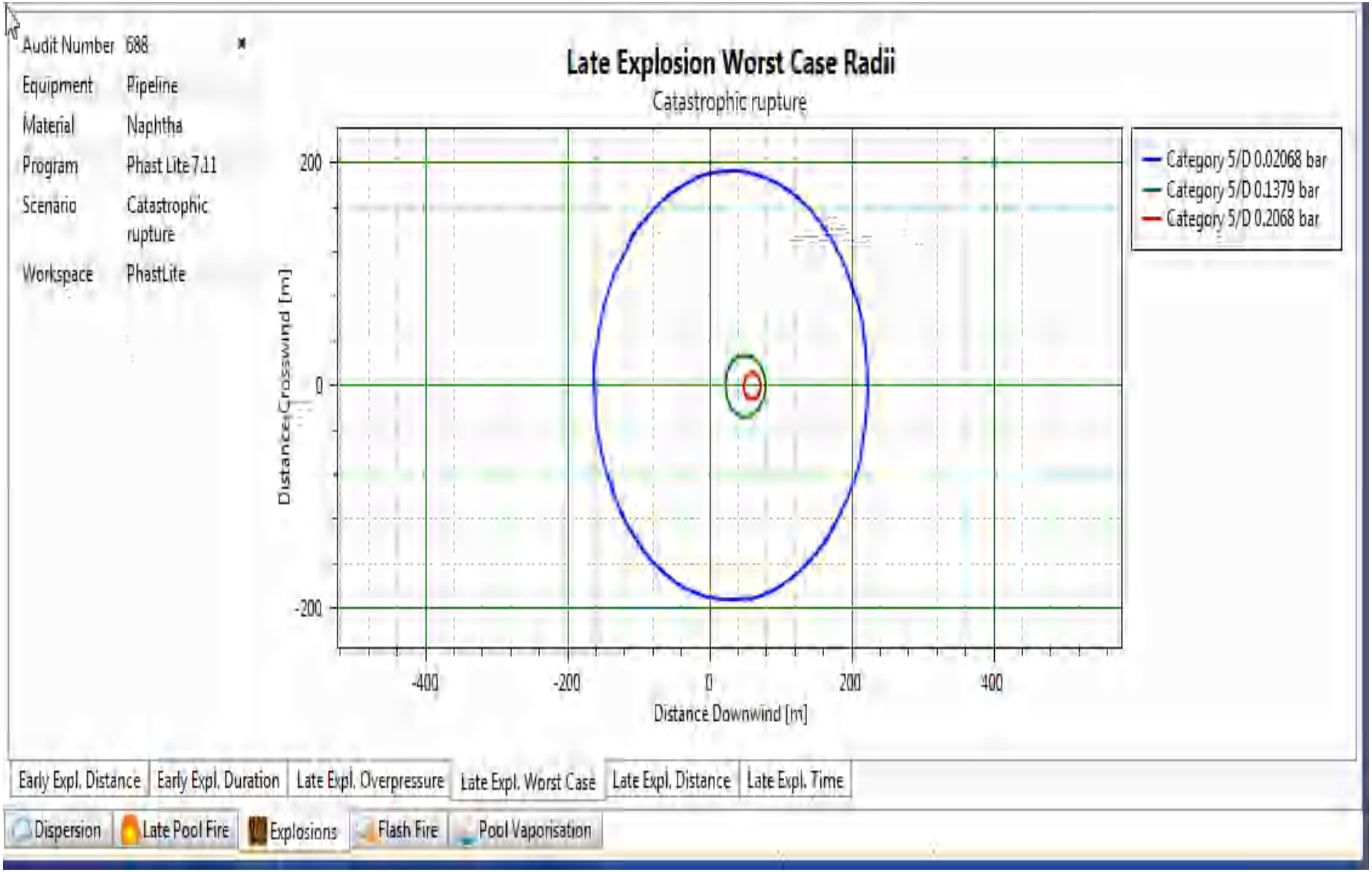


Figure 96:- Rupture graph of late Explosion Worst Case Radii from pipeline of Viramgam station.

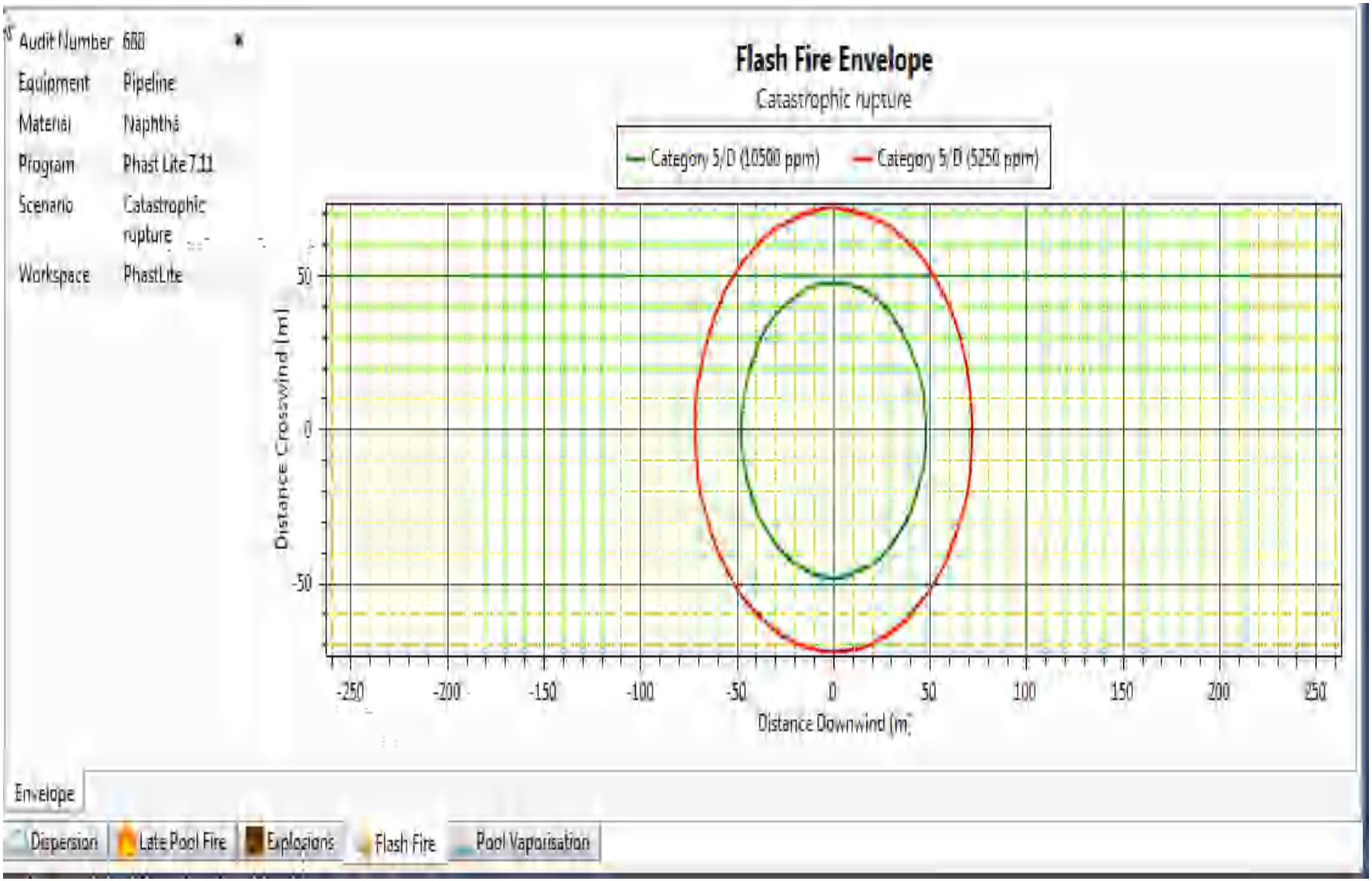


Figure 97:- Graph showing rupture of Flash Fire Envelope from pipeline of Viramgam station.

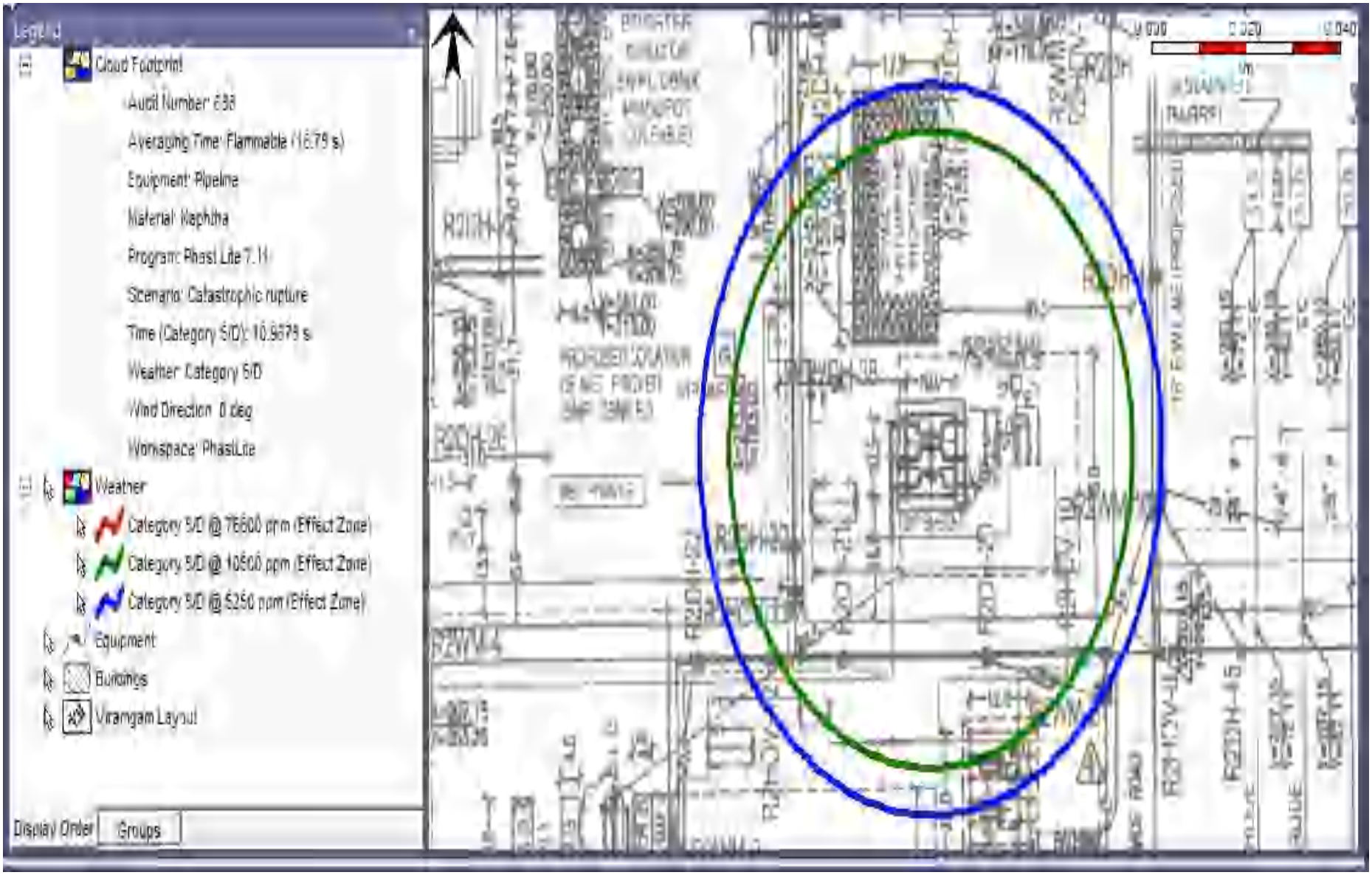


Figure 98:- Cloud Footprint of Viramgam station (Rupture of pipeline)

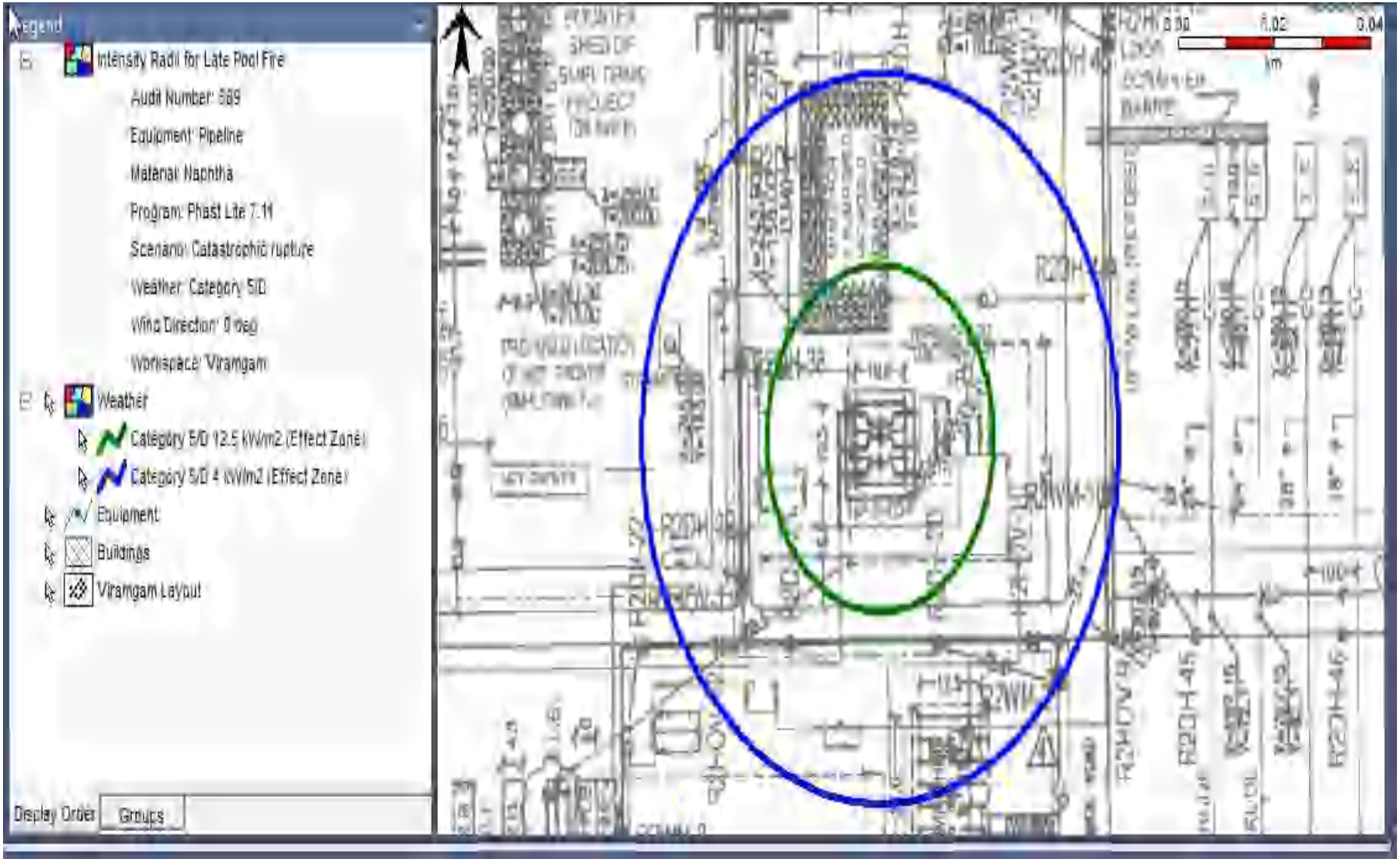


Figure 99:- Intensity Radii for Late Pool Fire of Viramgam station (Rupture of pipeline)

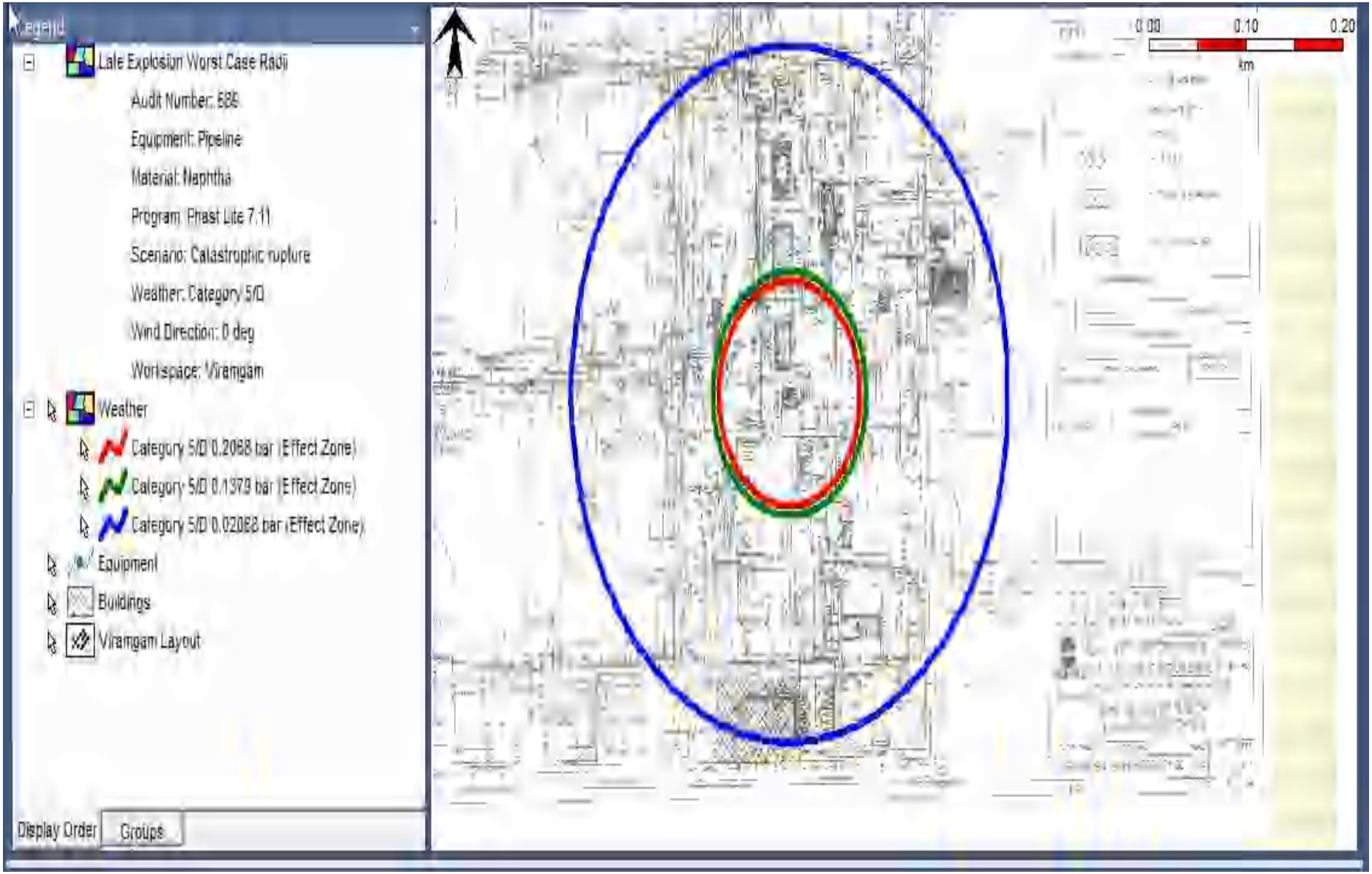


Figure 100:- Late Explosion Worst Case Radii of Viramgam station (Rupture of pipeline)

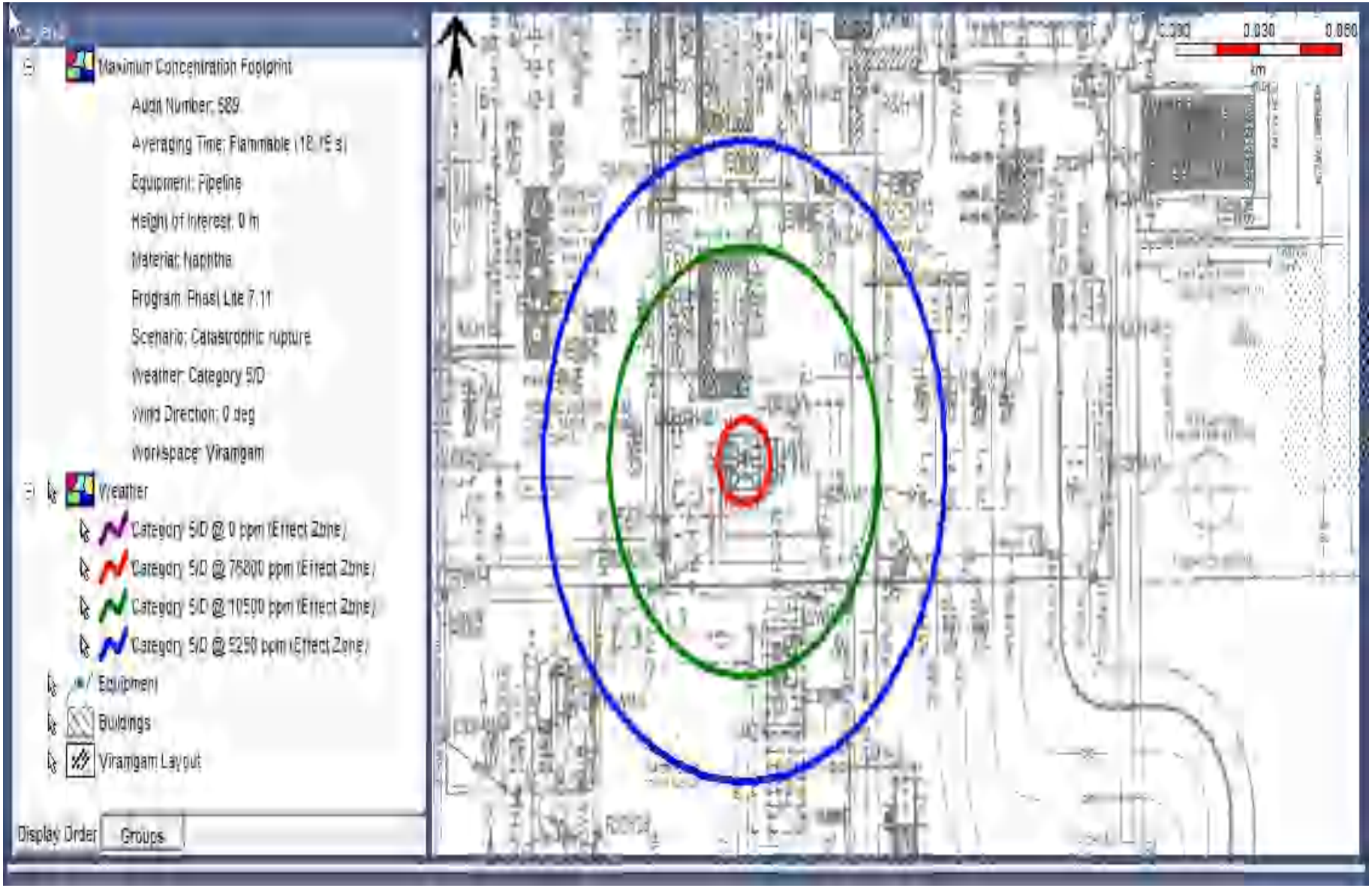


Figure 101:- Maximum Concentration Footprint of Viramgam station (Rupture of pipeline)

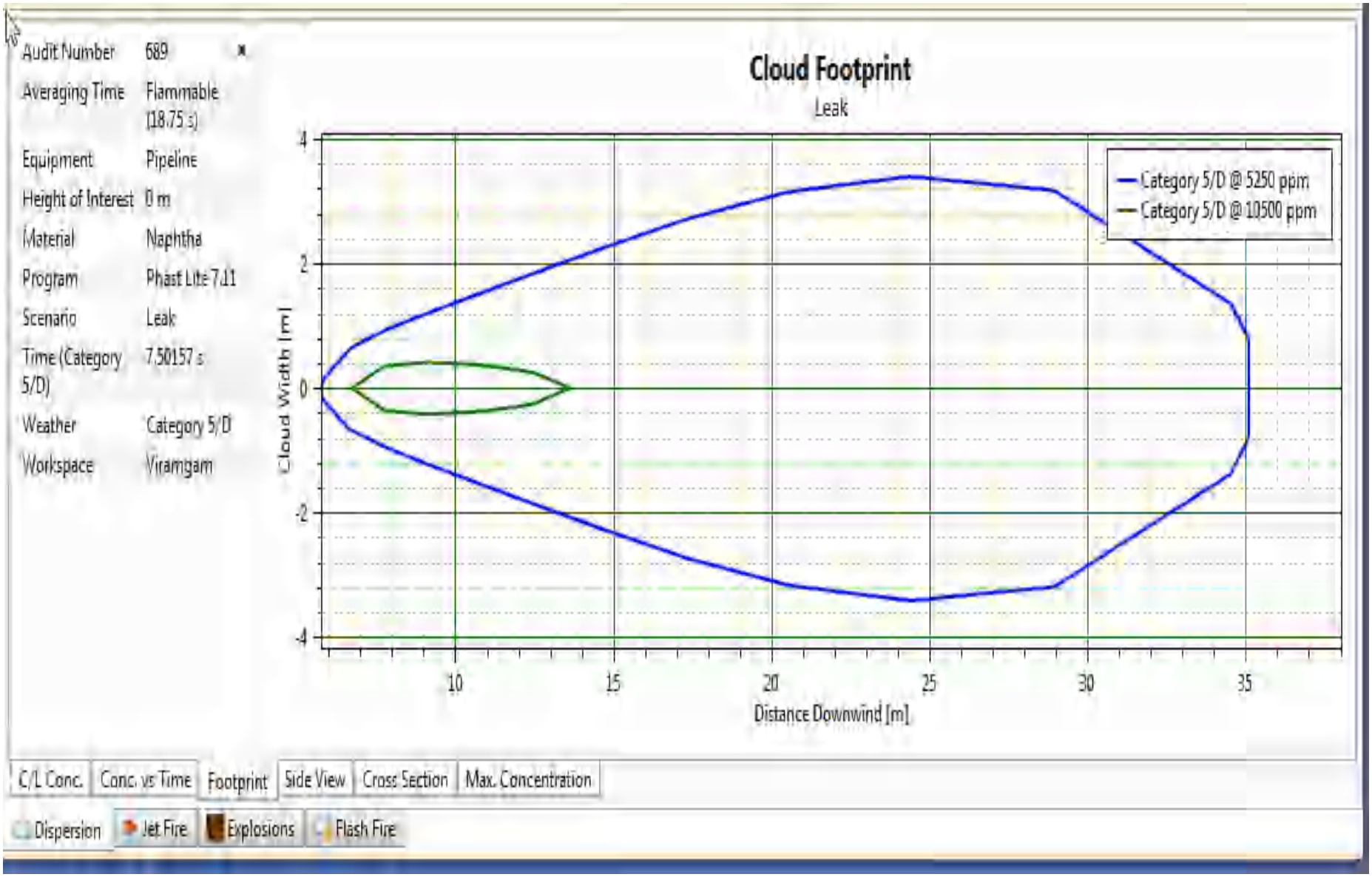


Figure 102:- Graph showing leak of Cloud Footprint from pipeline of Viramgam station.

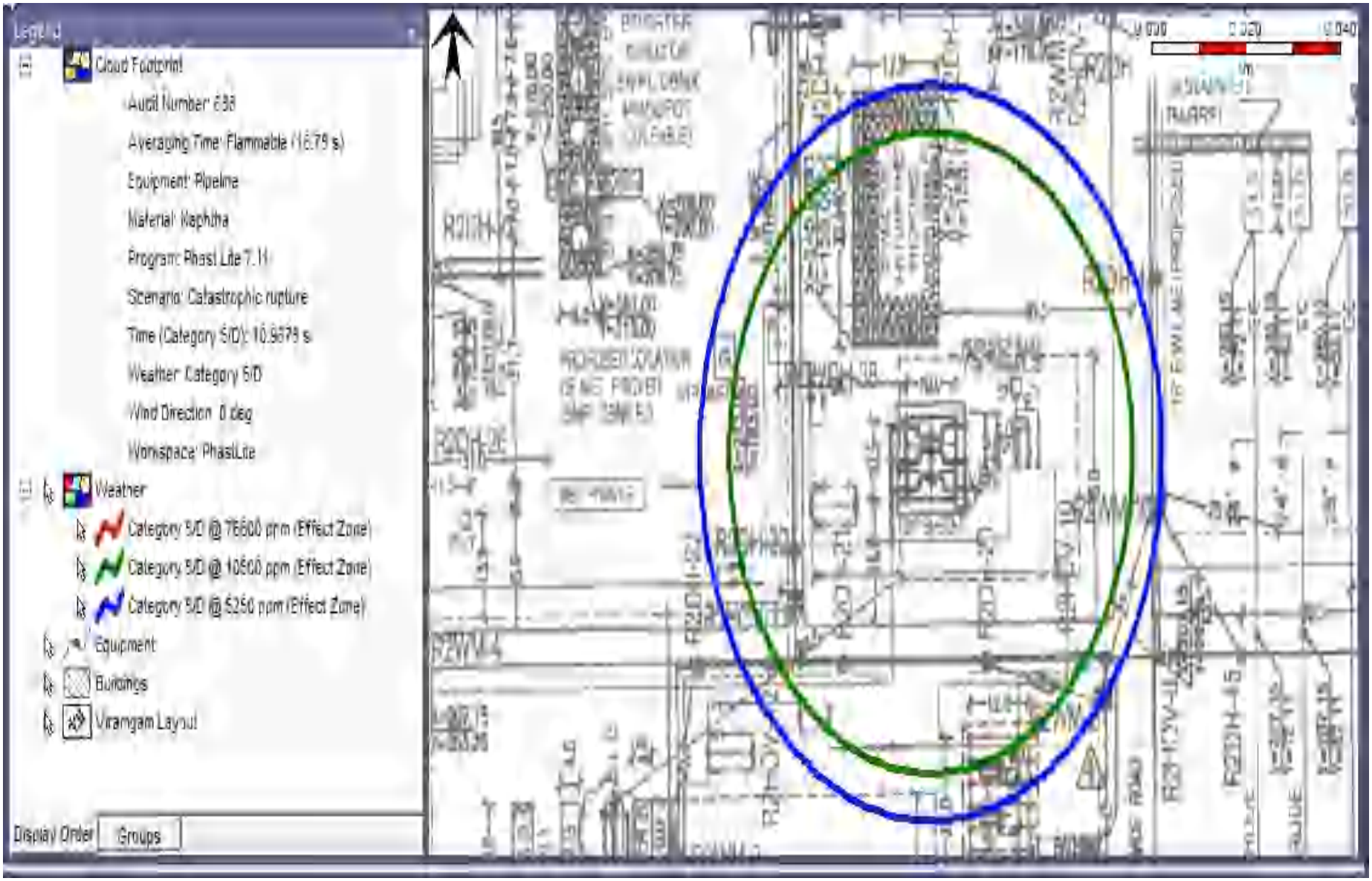


Figure 103:- Cloud Footprint of Viramgam station (Rupture of pipeline)

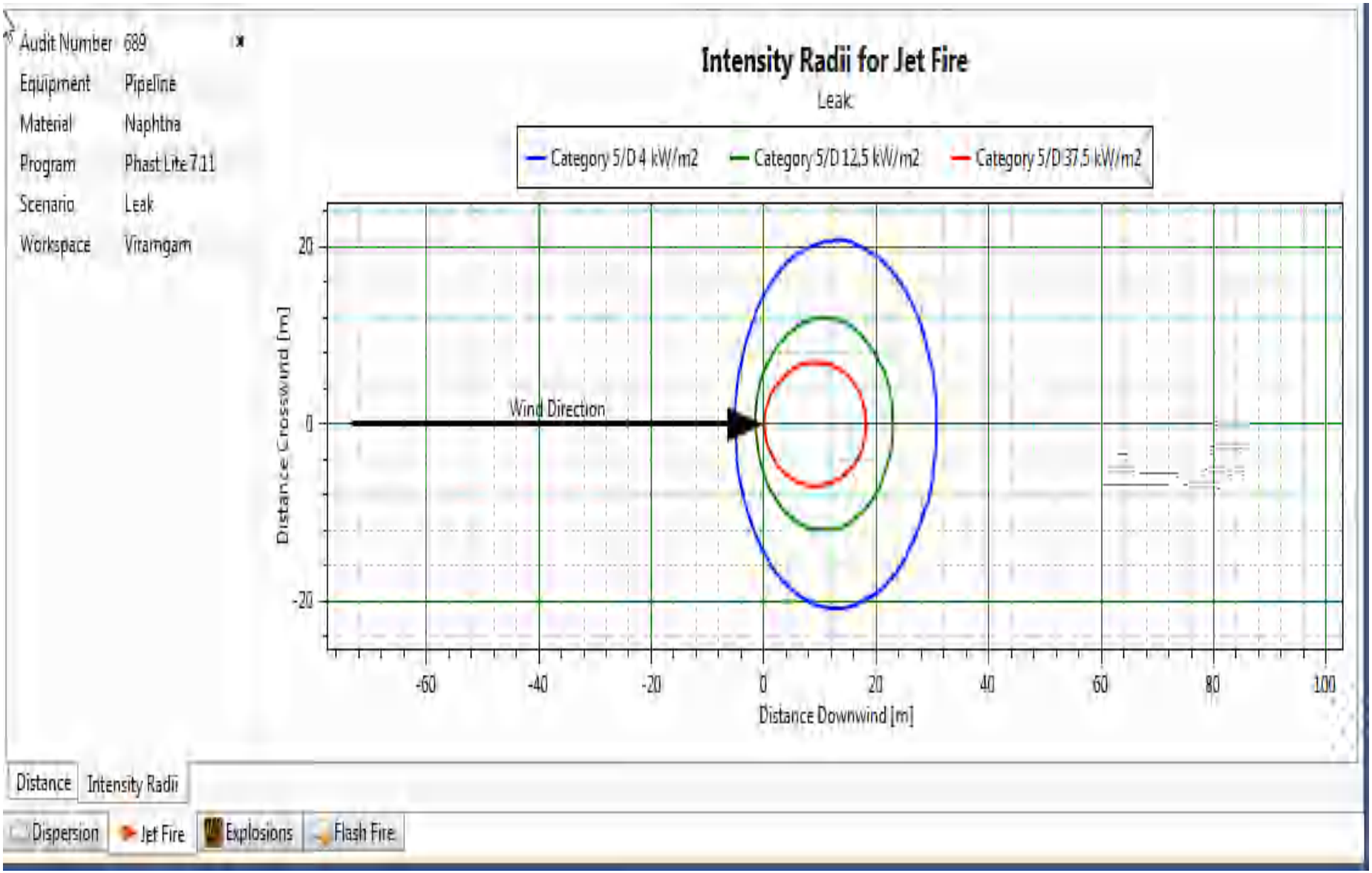


Figure 104:- Leak graph of Intensity Radii for Jet Fire from pipeline of Viramgam station.

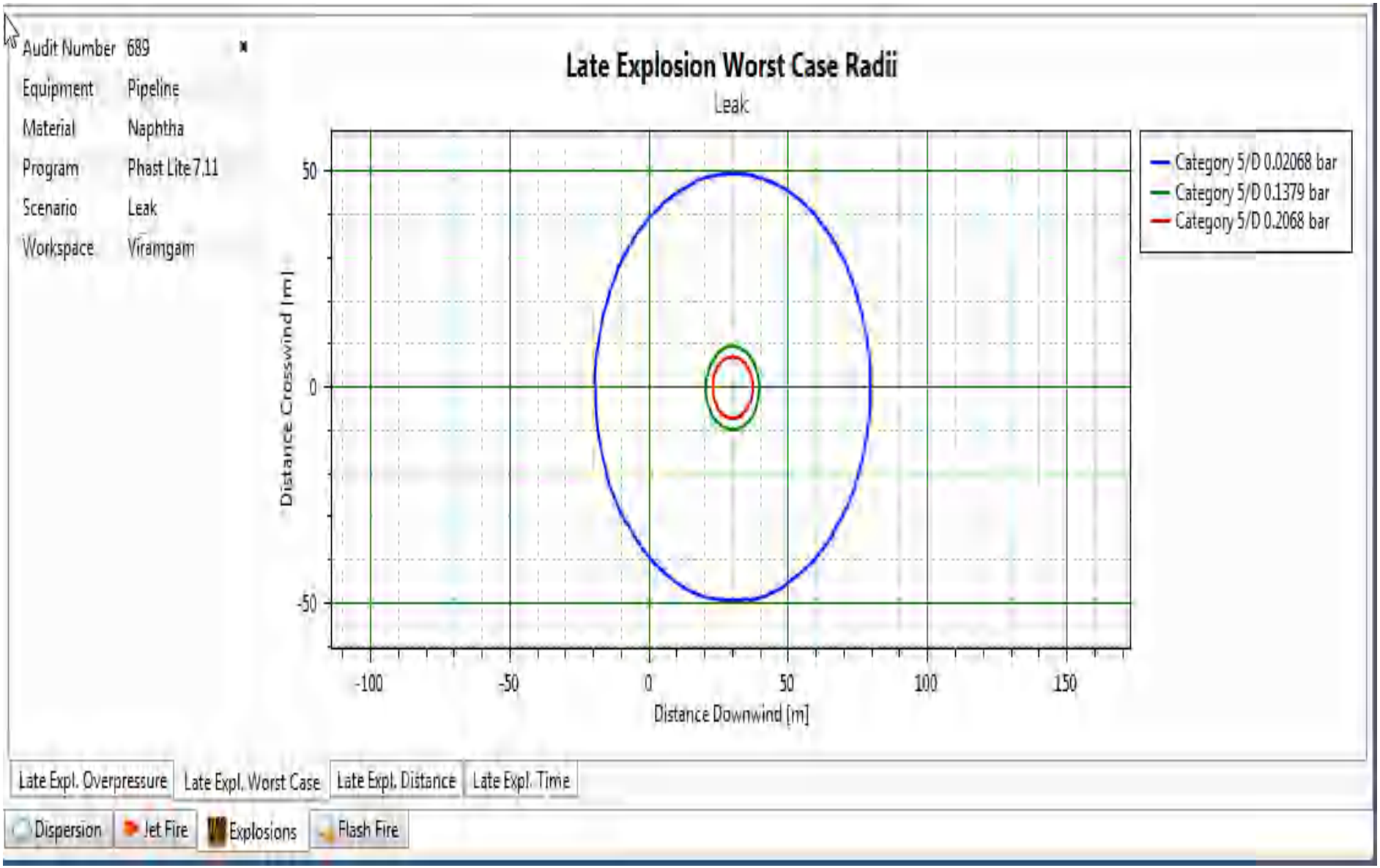


Figure 105:- Leak graph of late Explosion Worst Case Radii from pipeline of Viramgam station.

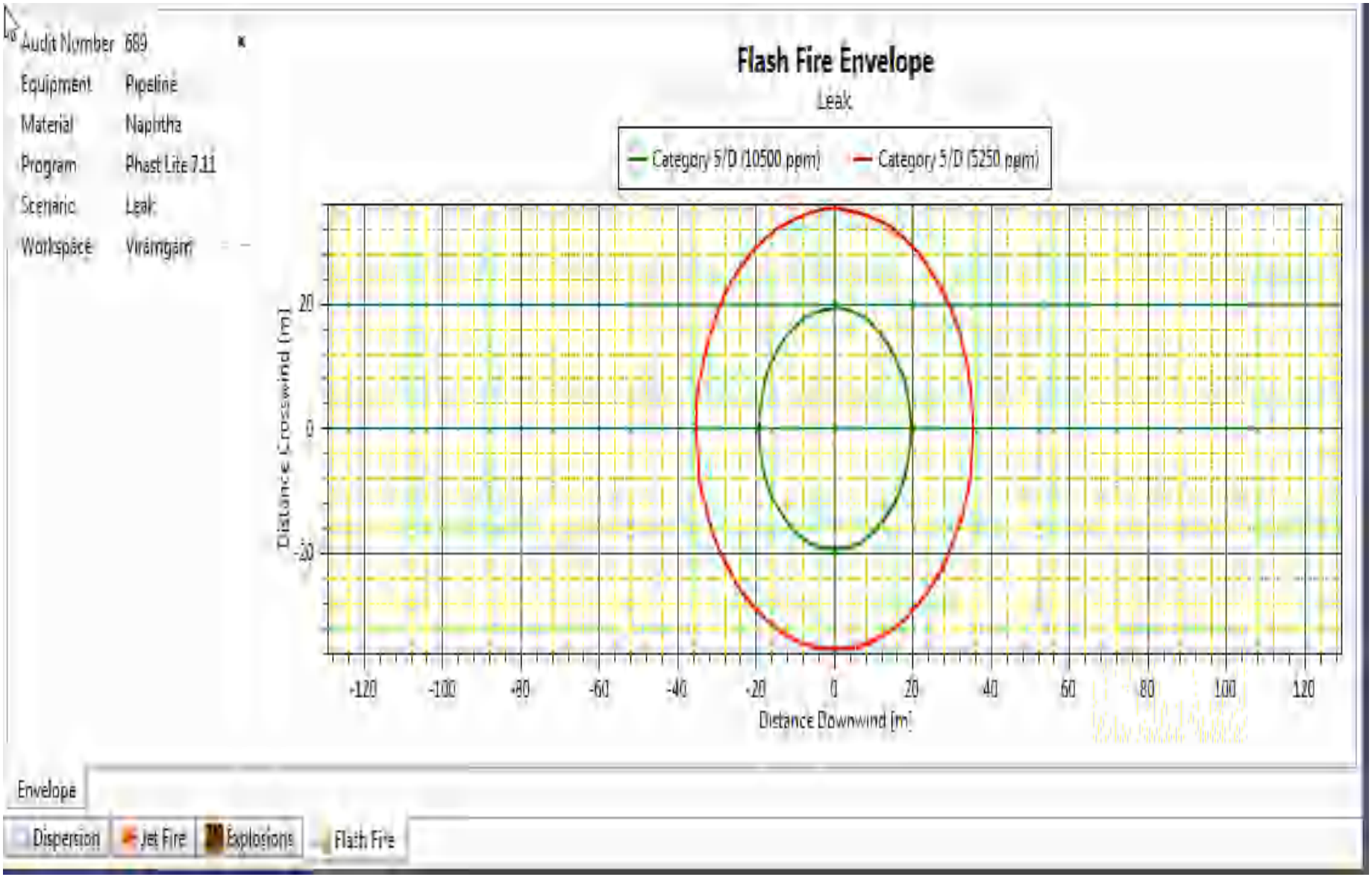


Figure 106:- Leak graph of Flash Fire Envelope from pipeline of Viramgam station.

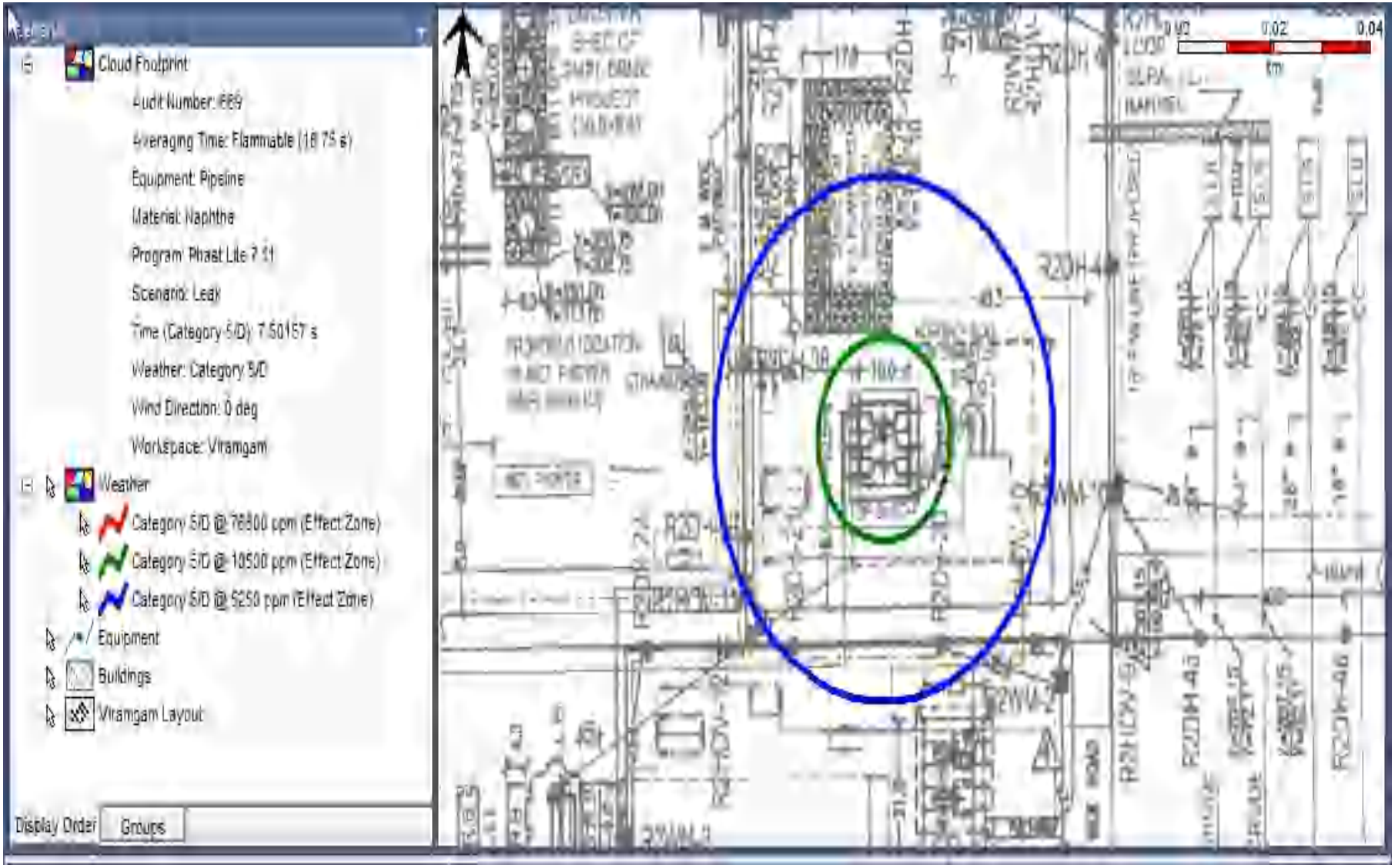


Figure 107:- Cloud Footprint of Viramgam station (Leak of pipeline)

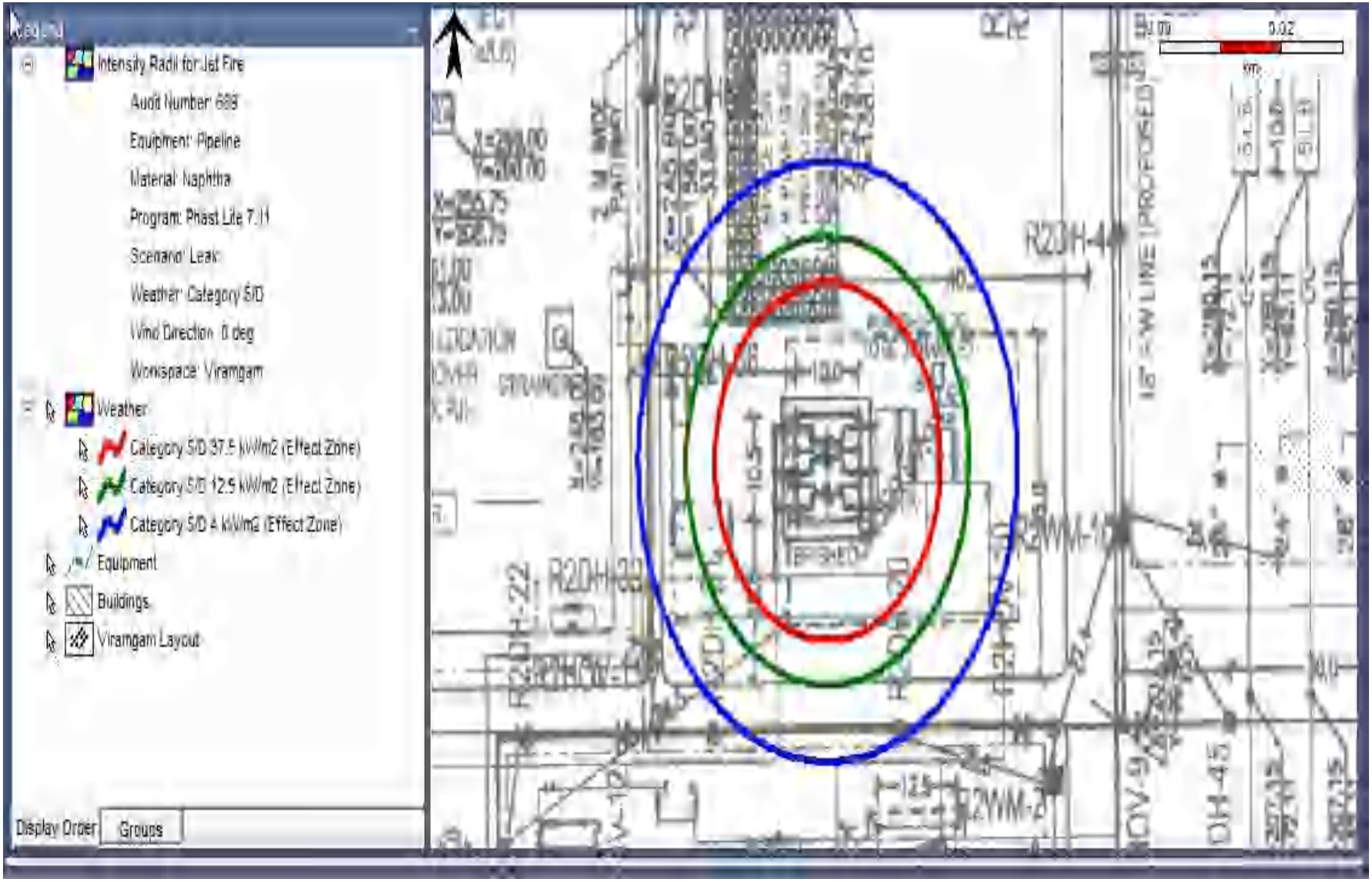


Figure 108:- Intensity Radii for Jet Fire of Viramagm station (Leak of pipeline)

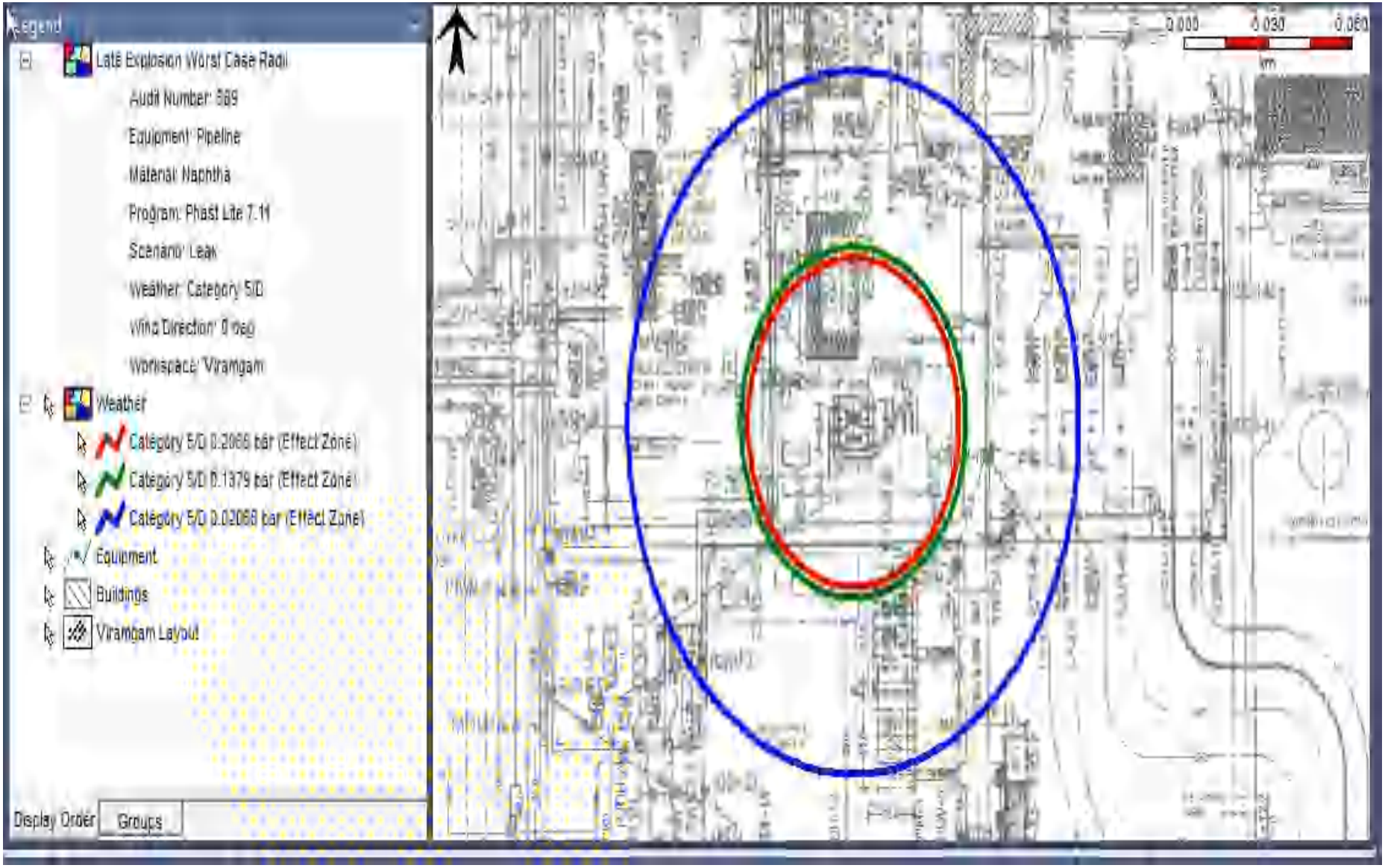


Figure 109:- Late Explosion Worst Case Radii of Viramgam station (Leak of pipeline)

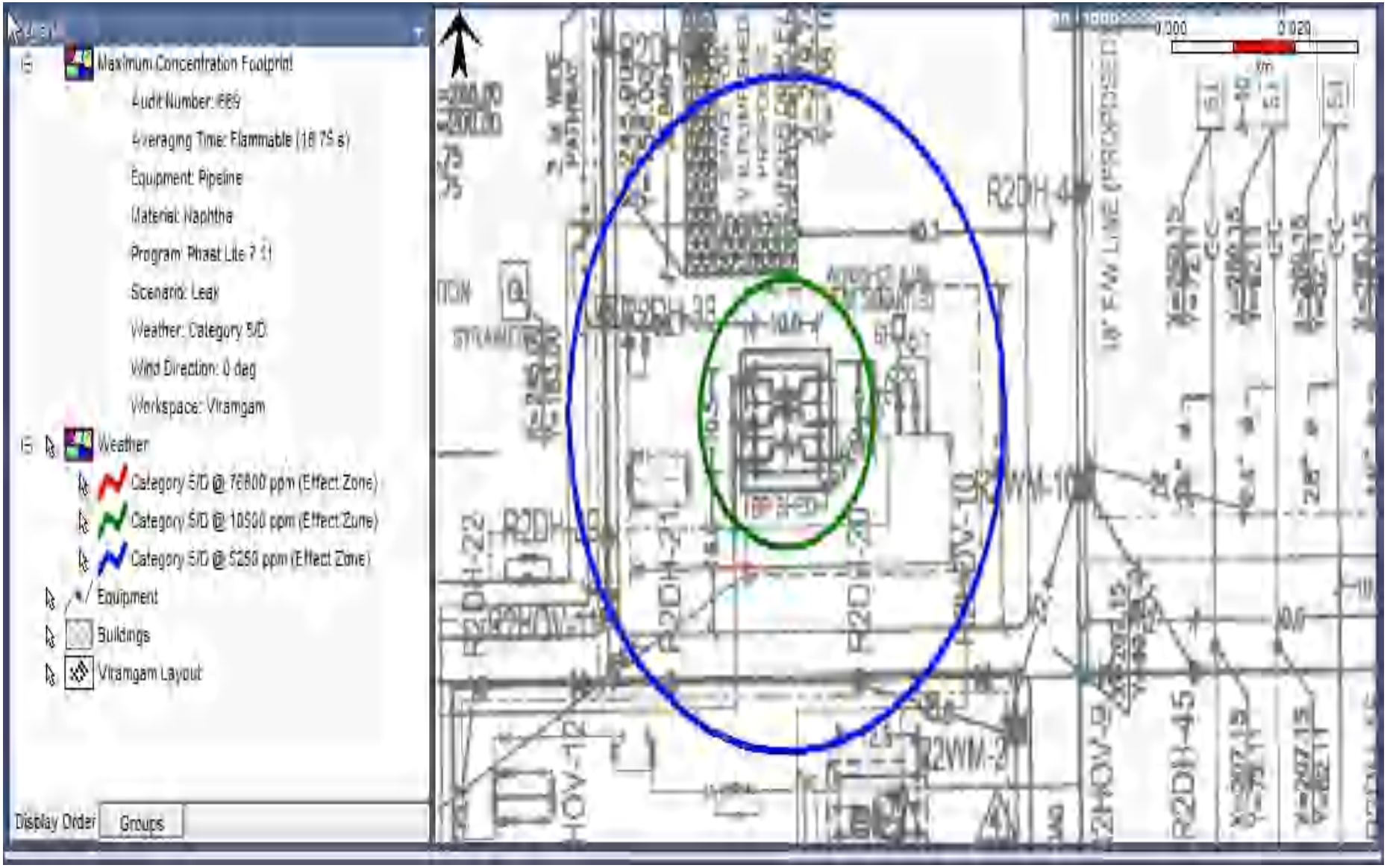


Figure 110:- Maximum Concentration Footprint of Viramgam station (Leak of pipeline)

KOYALI

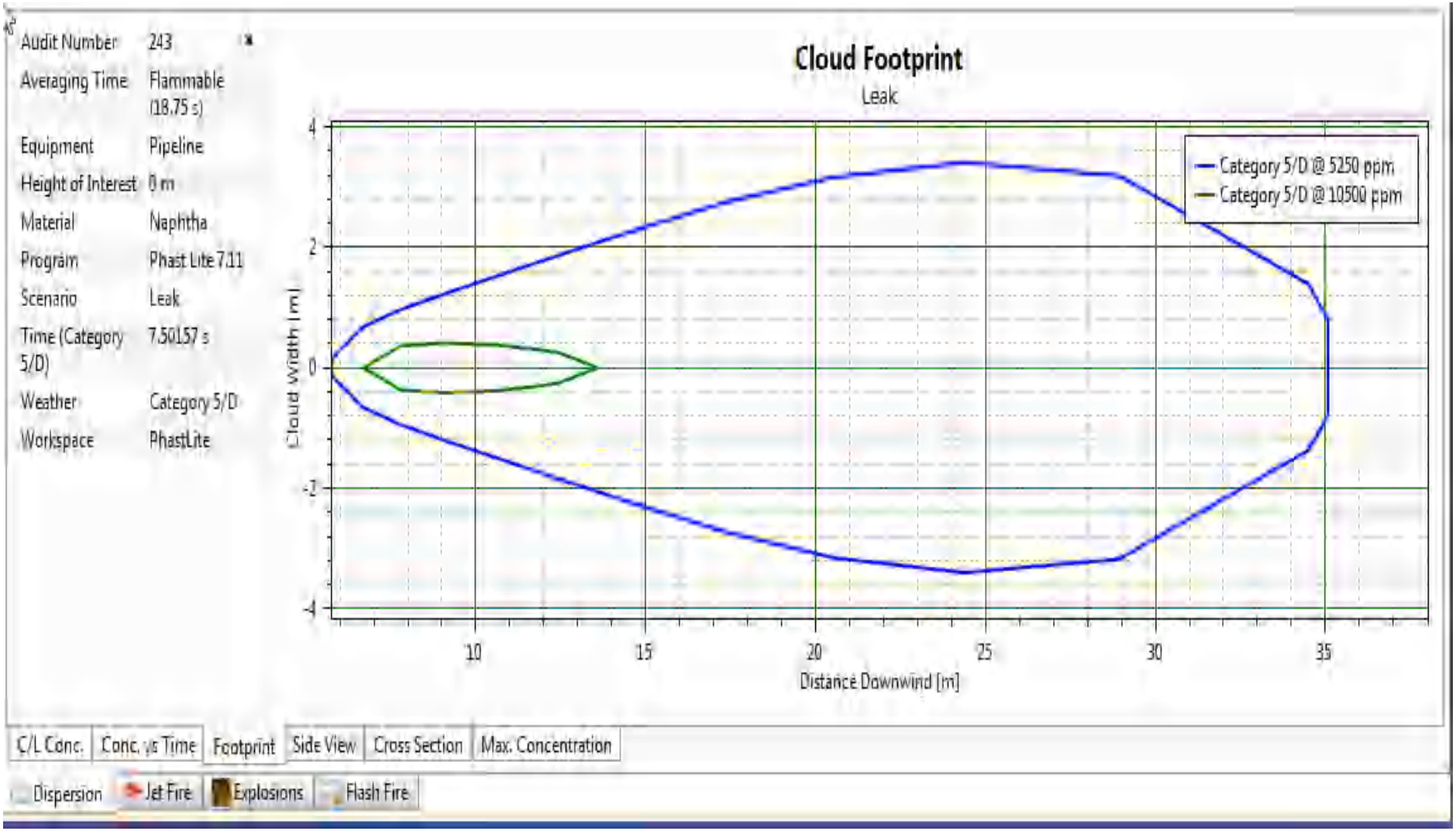


Figure 111:- Graph showing leak of Cloud Footprint from pipeline of Koyali station.

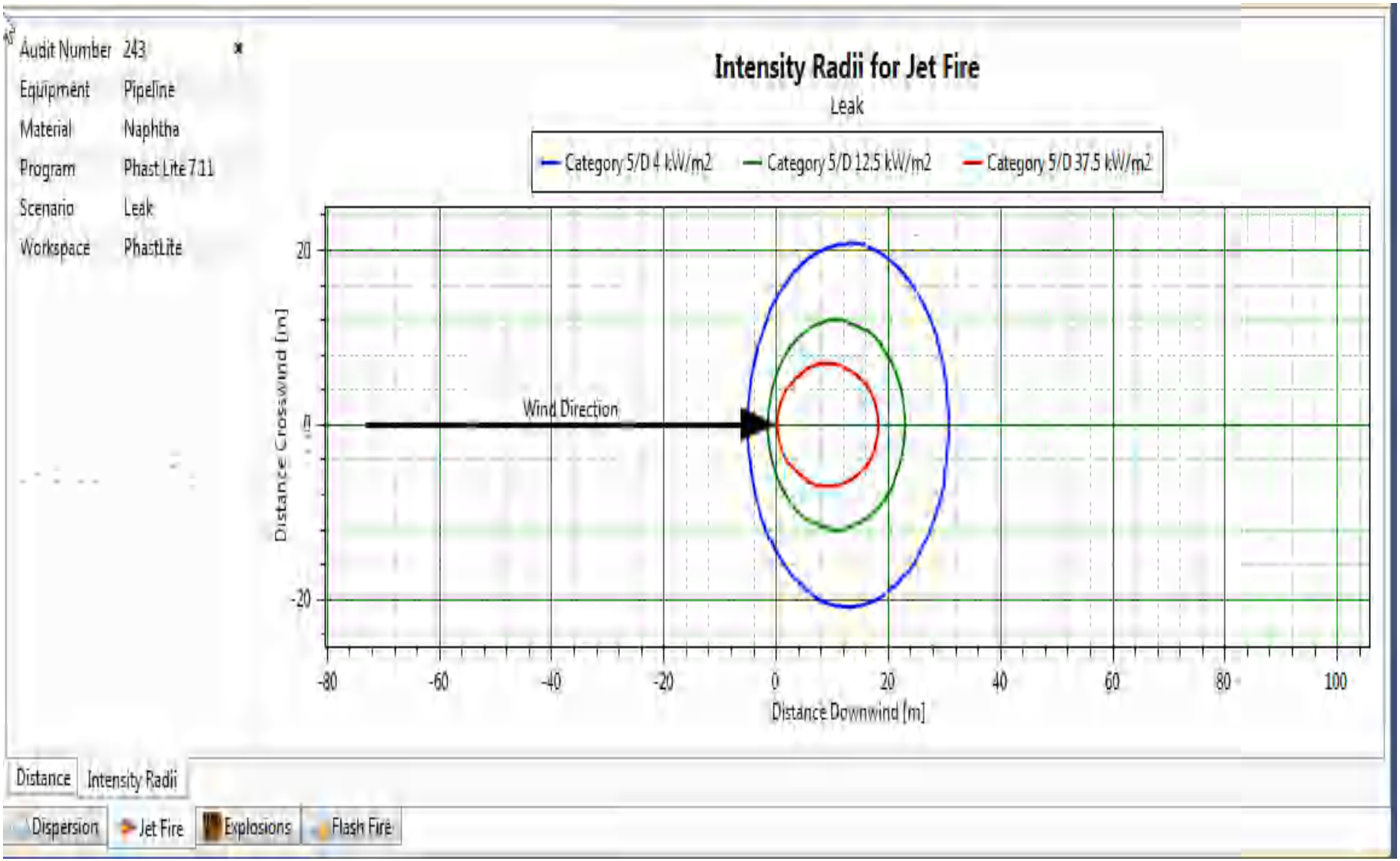


Figure 112:- Graph showing leak of Intensity Radii for Jet Fire from pipeline of Koyali station.

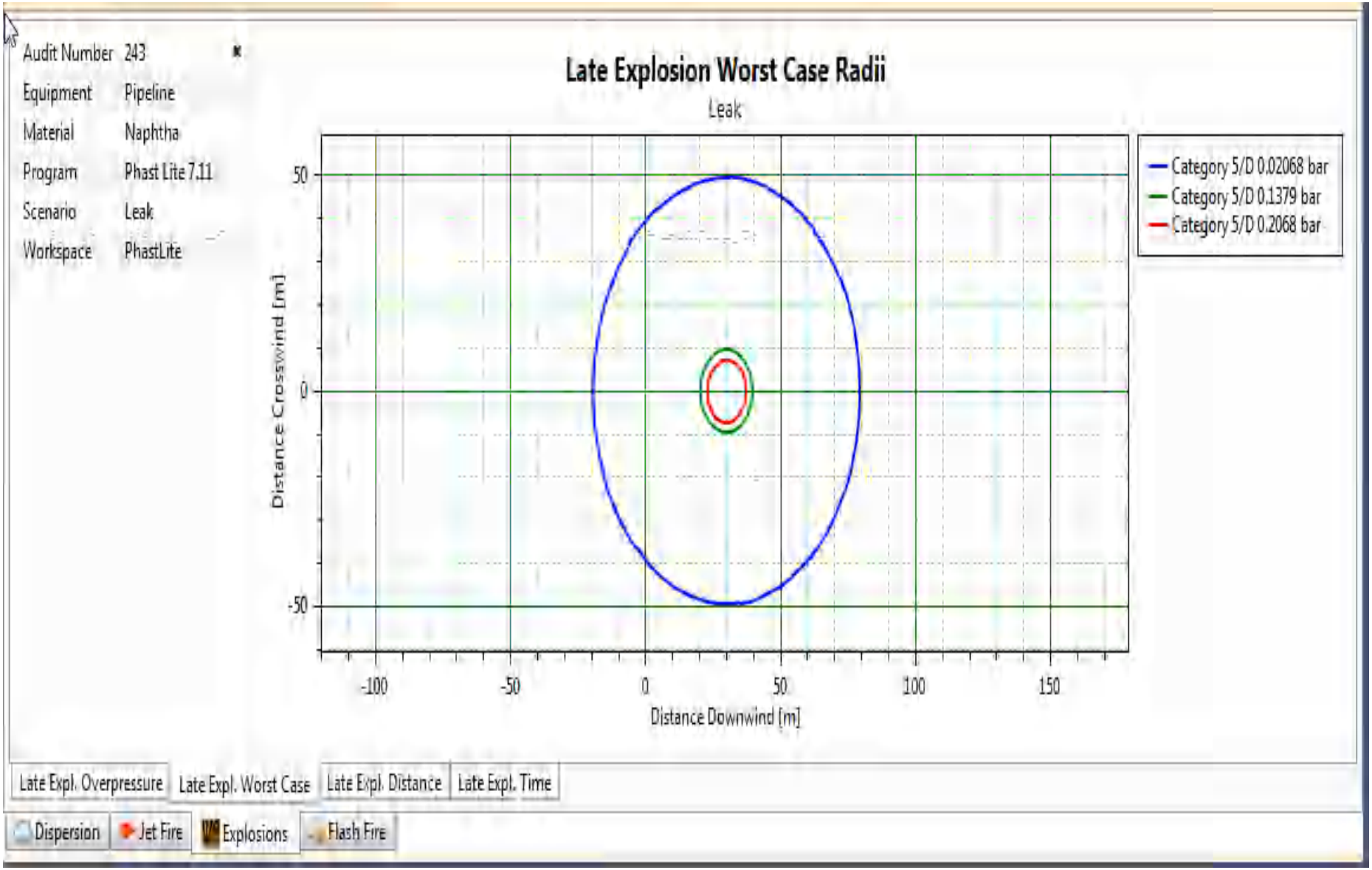


Figure 113:- Graph showing leak of Late Explosion Worst Case Radii from pipeline of Koyali station.

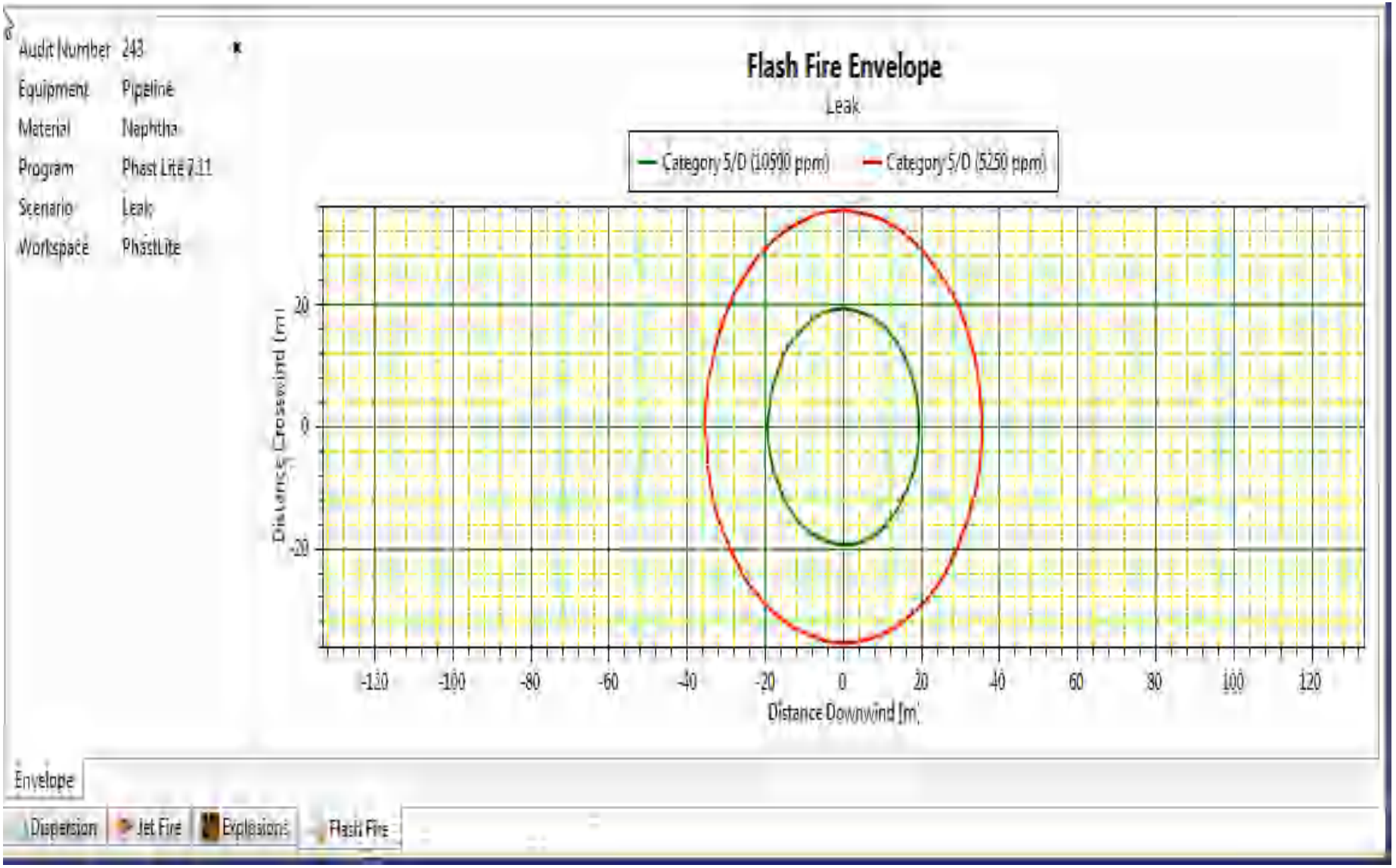


Figure 114:- Graph showing leak of Flash Fire Envelope from pipeline of Koyali station.

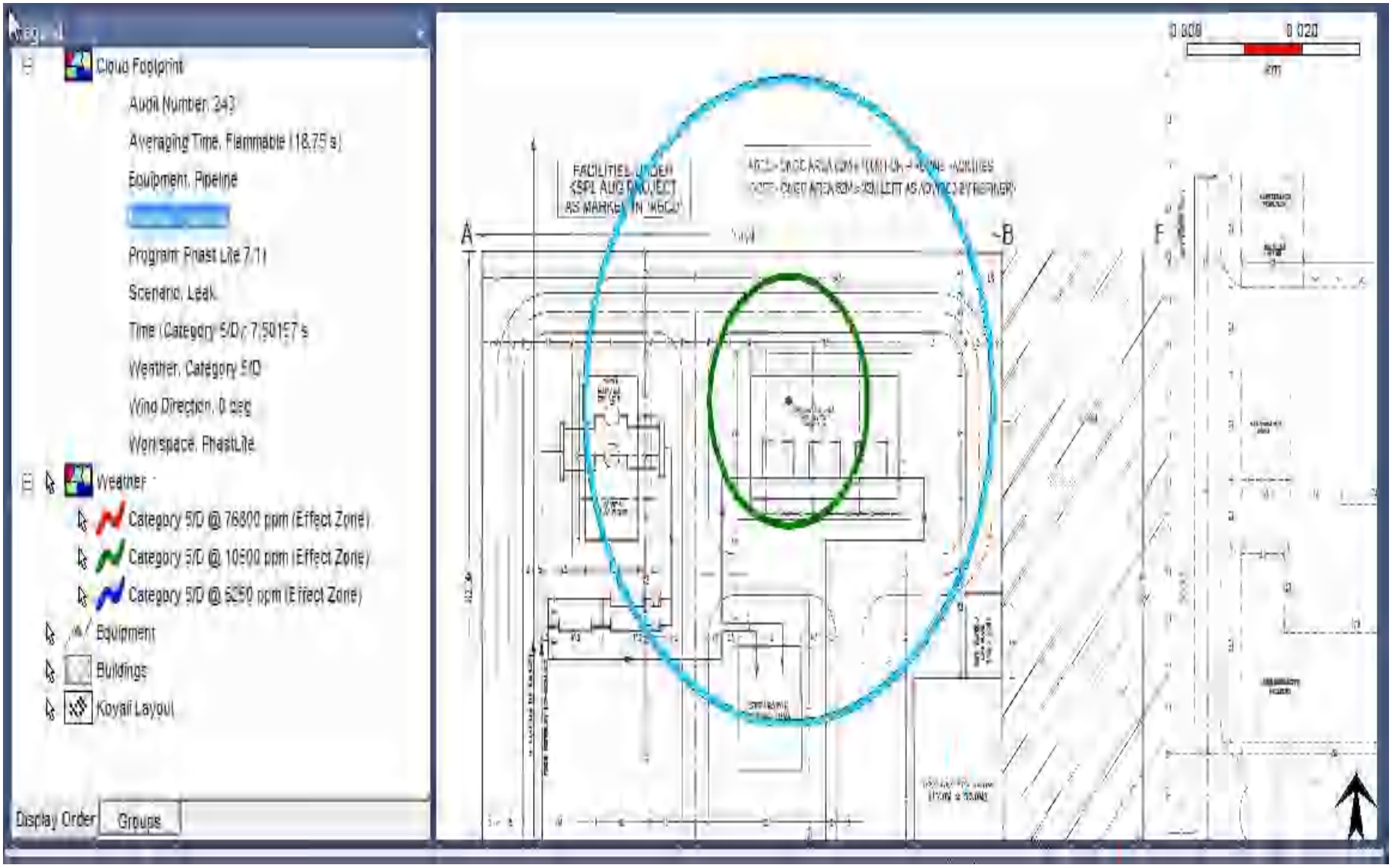


Figure 115:- Cloud Footprint of Koyali station (Leak of pipeline)

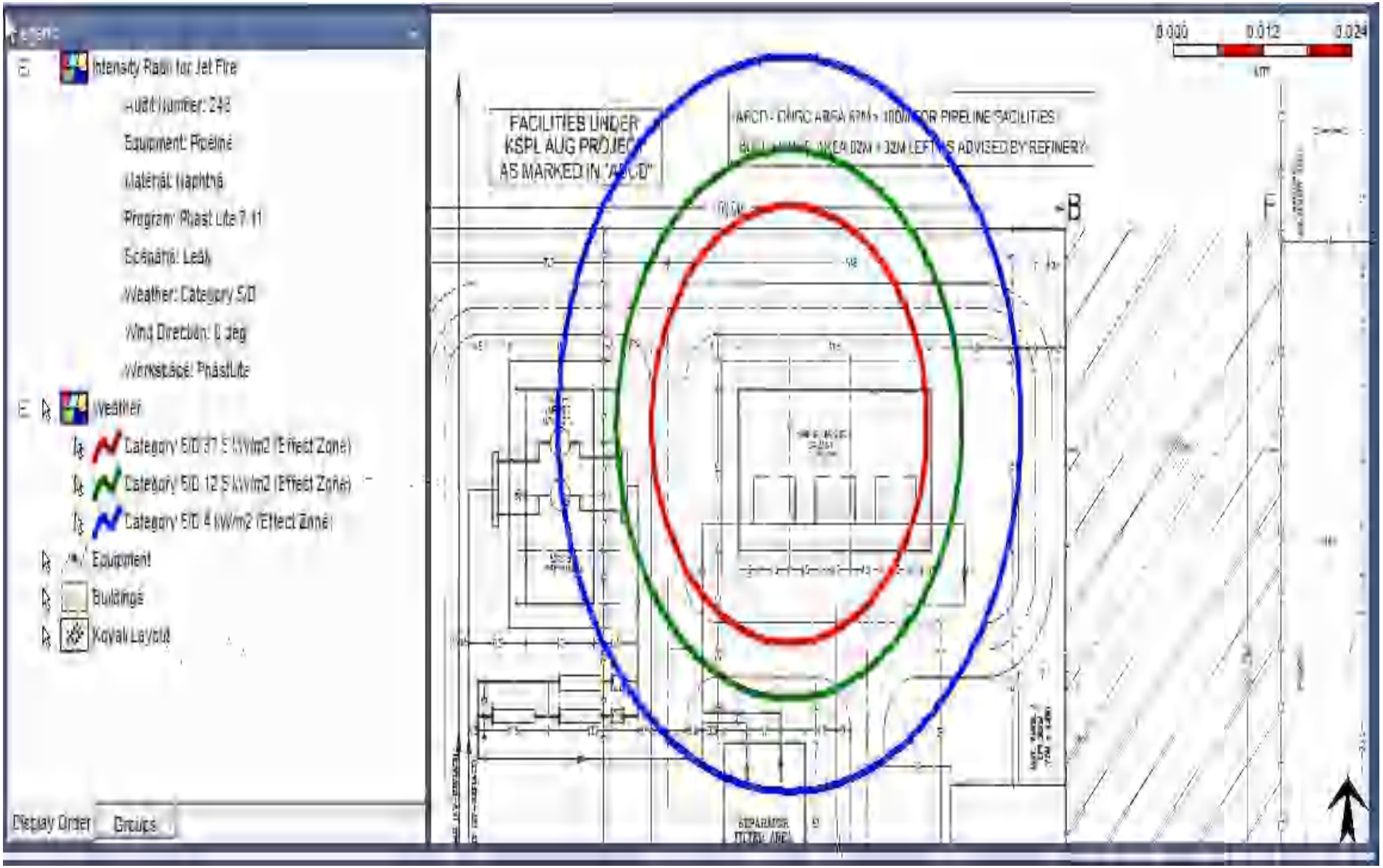


Figure 116:- Intensity Radii for Jet Fire of Koyali station (Leak of pipeline)

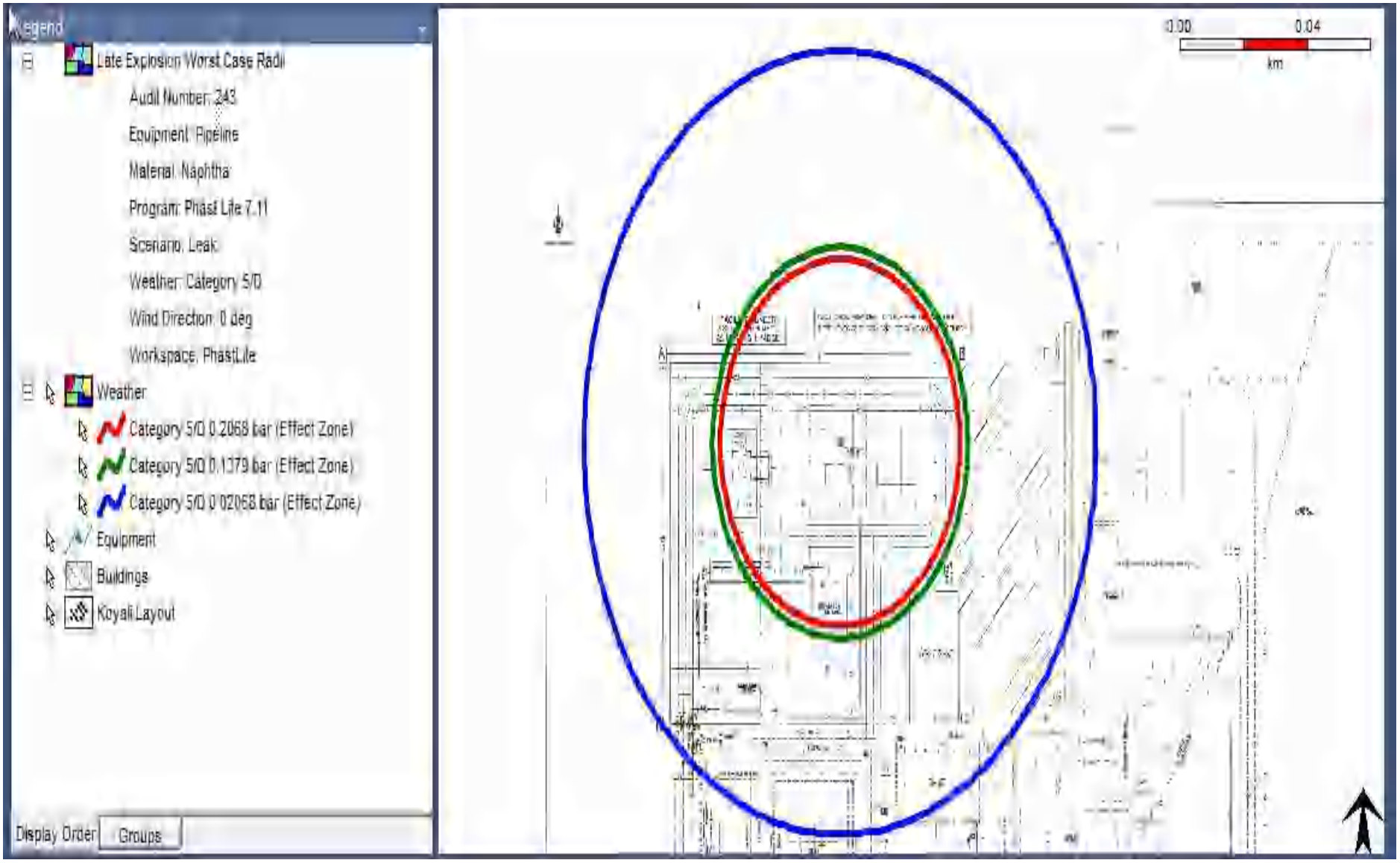


Figure 117:- Late Explosion Worst Case Radii of Koyali station (Leak of pipeline)

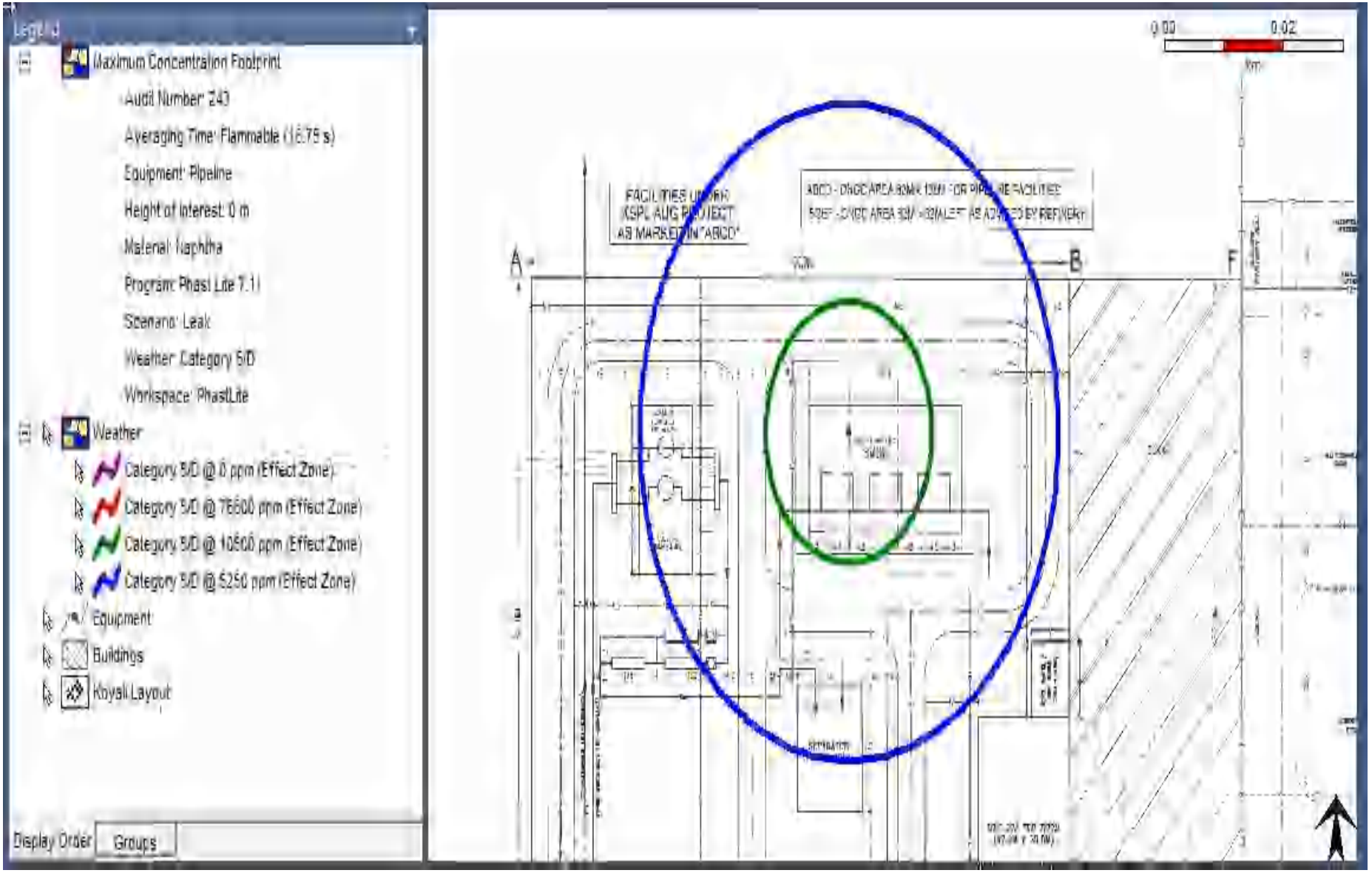


Figure 118:- Maximum Concentration Footprint of Koyali station (Leak of pipeline)

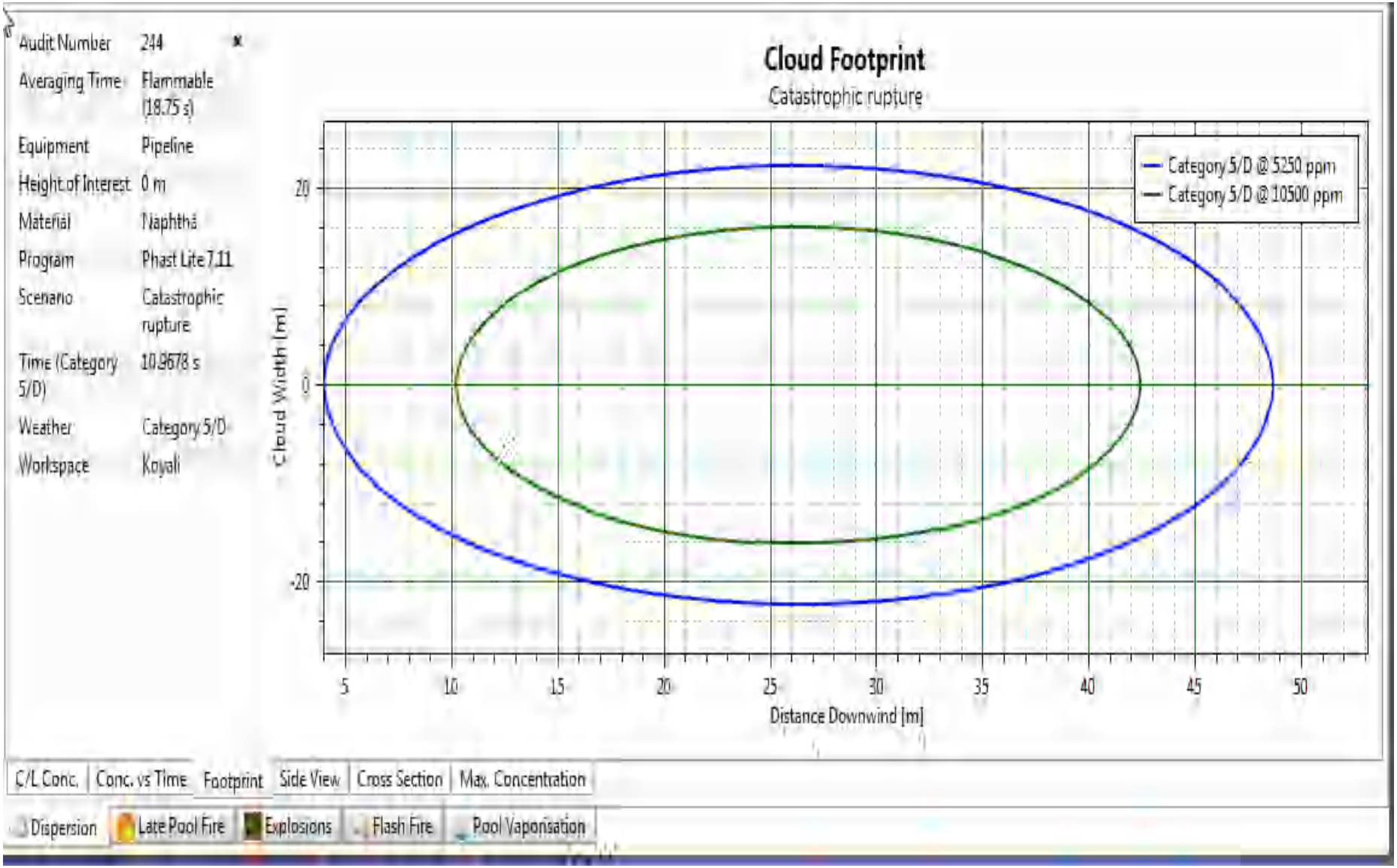


Figure 119:- Graph showing rupture of Cloud Footprint from pipeline of Koyali station.

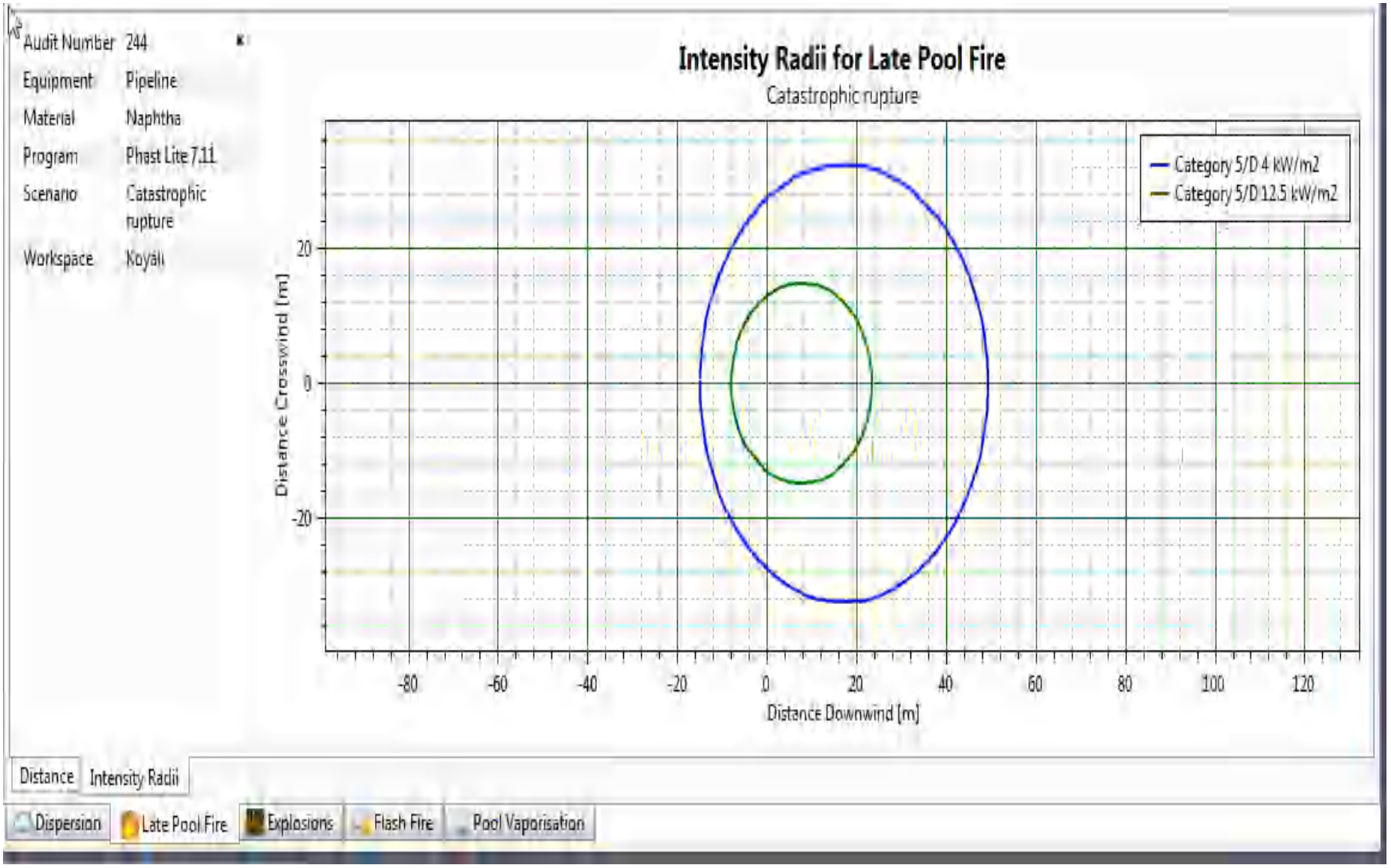


Figure 120:- Graph showing rupture of Intensity Radii of Pool Fire from pipeline of Koyali station.

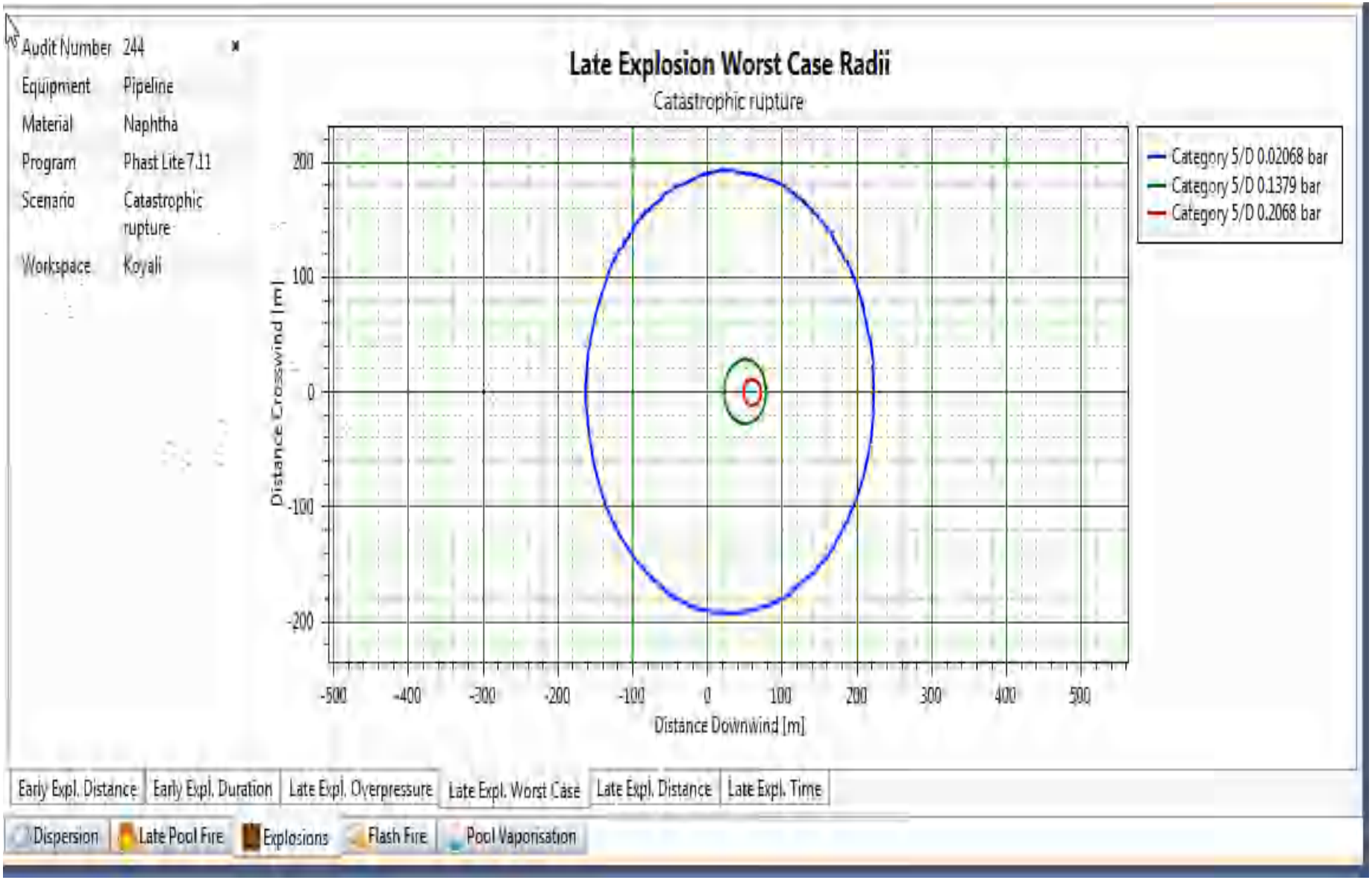


Figure 121:- Rupture graph of late Explosion Worst Case Radii from pipeline of Koyali station.

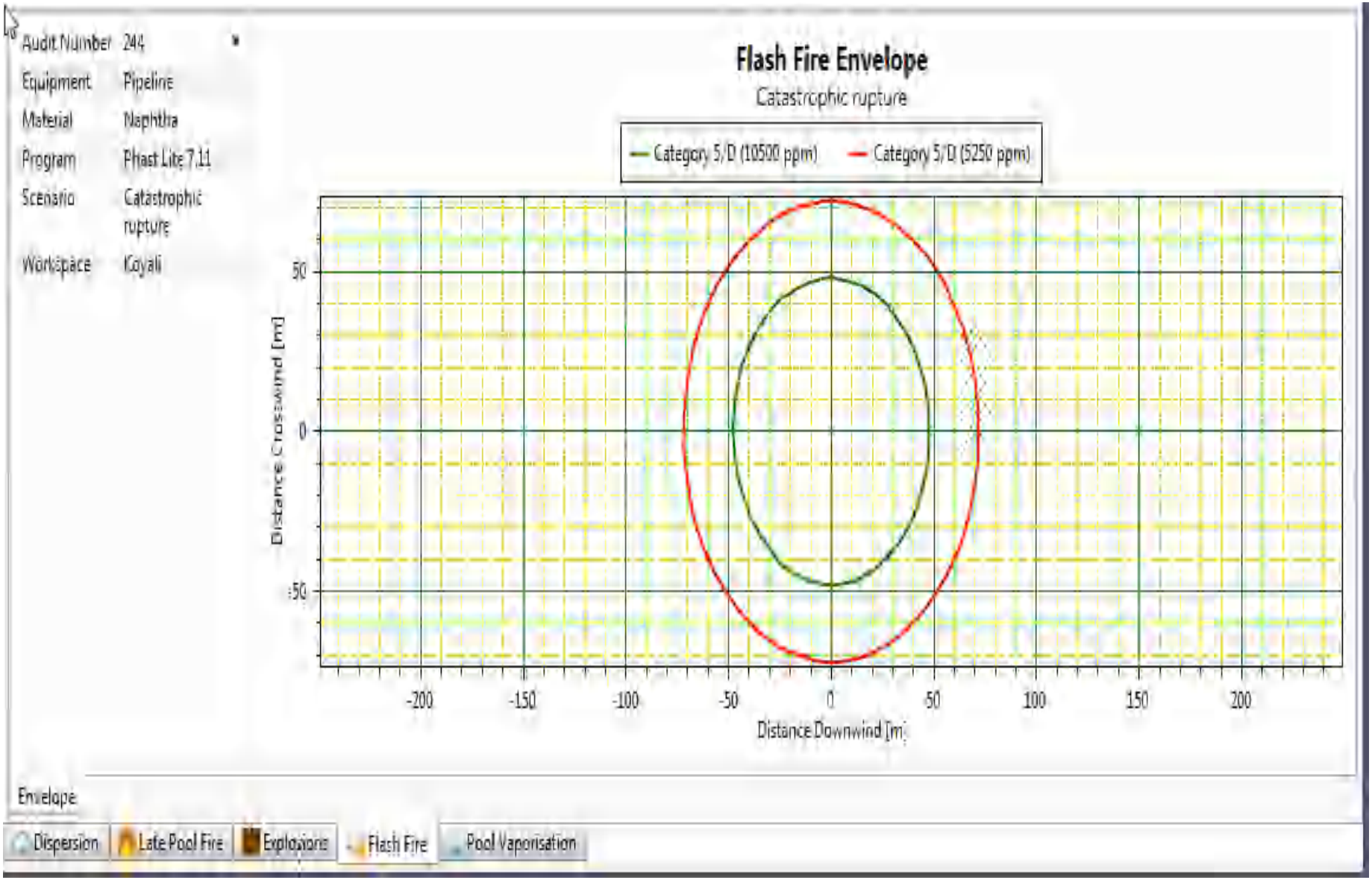


Figure 122:- Graph showing rupture of Flash Fire Envelope from pipeline of Koyali station.

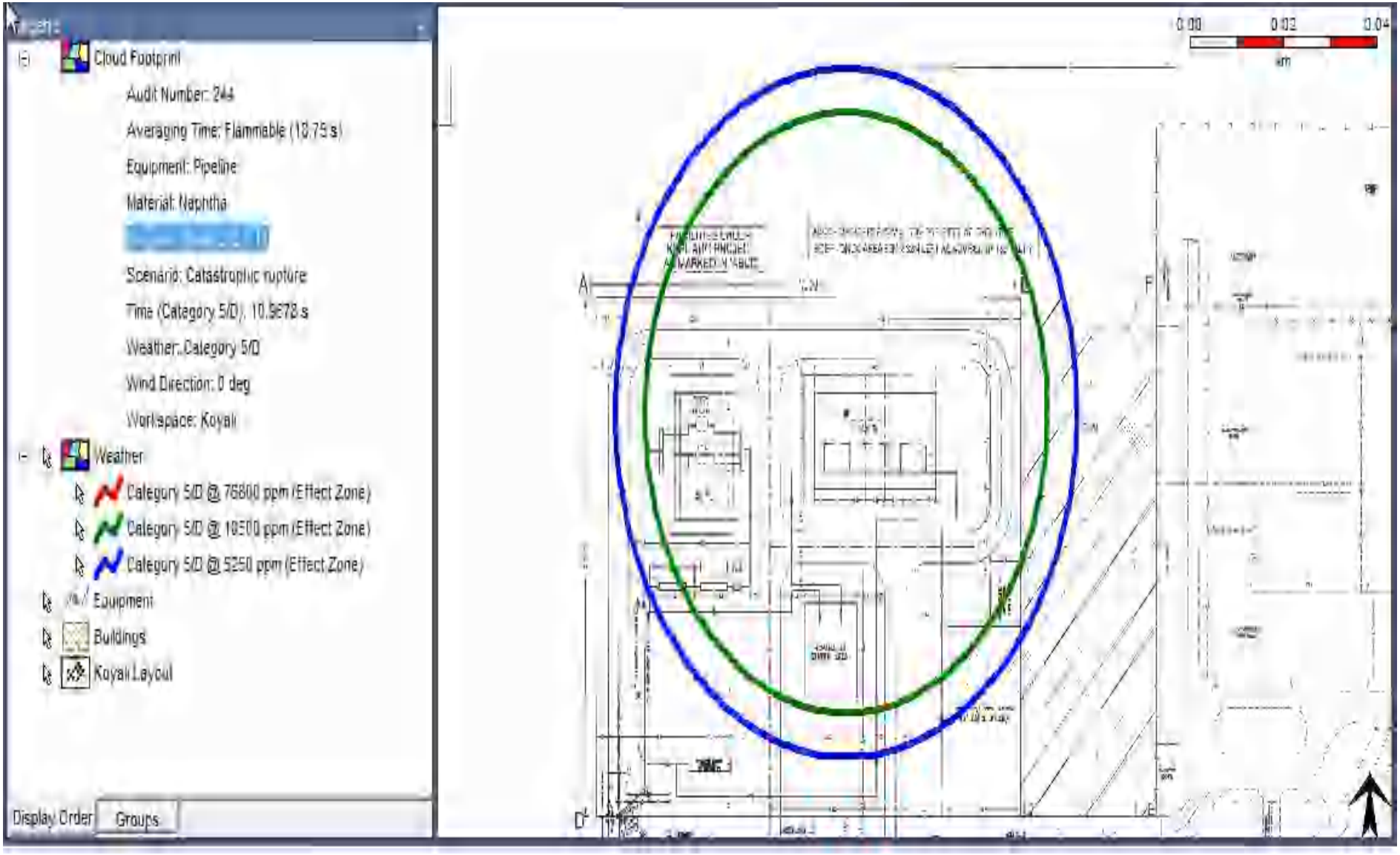


Figure 123:- Cloud Footprint of Koyali station (Rupture of pipeline)

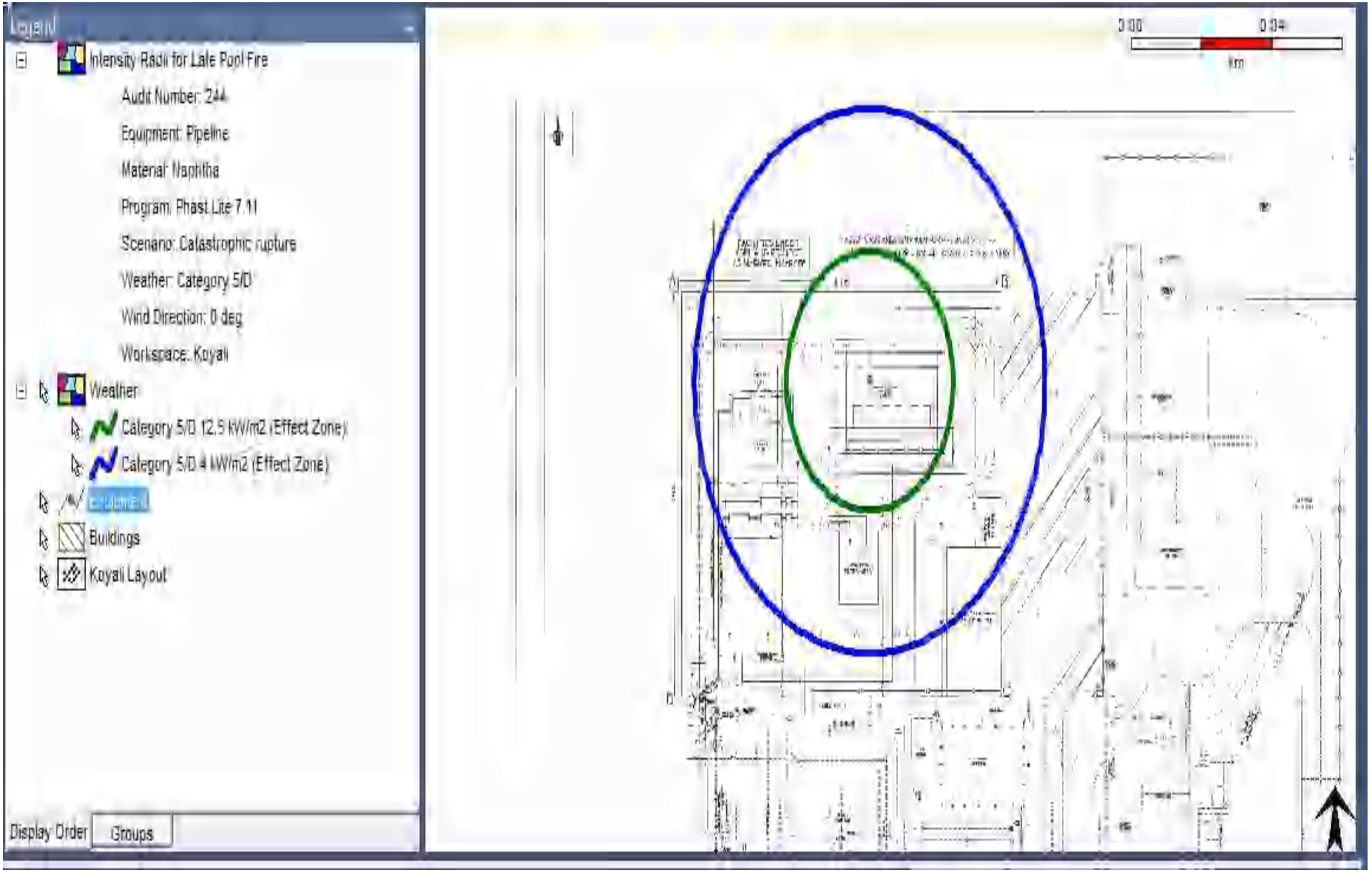


Figure 124:- Intensity Radii for Late Pool Fire of Koyali station (Rupture of pipeline)

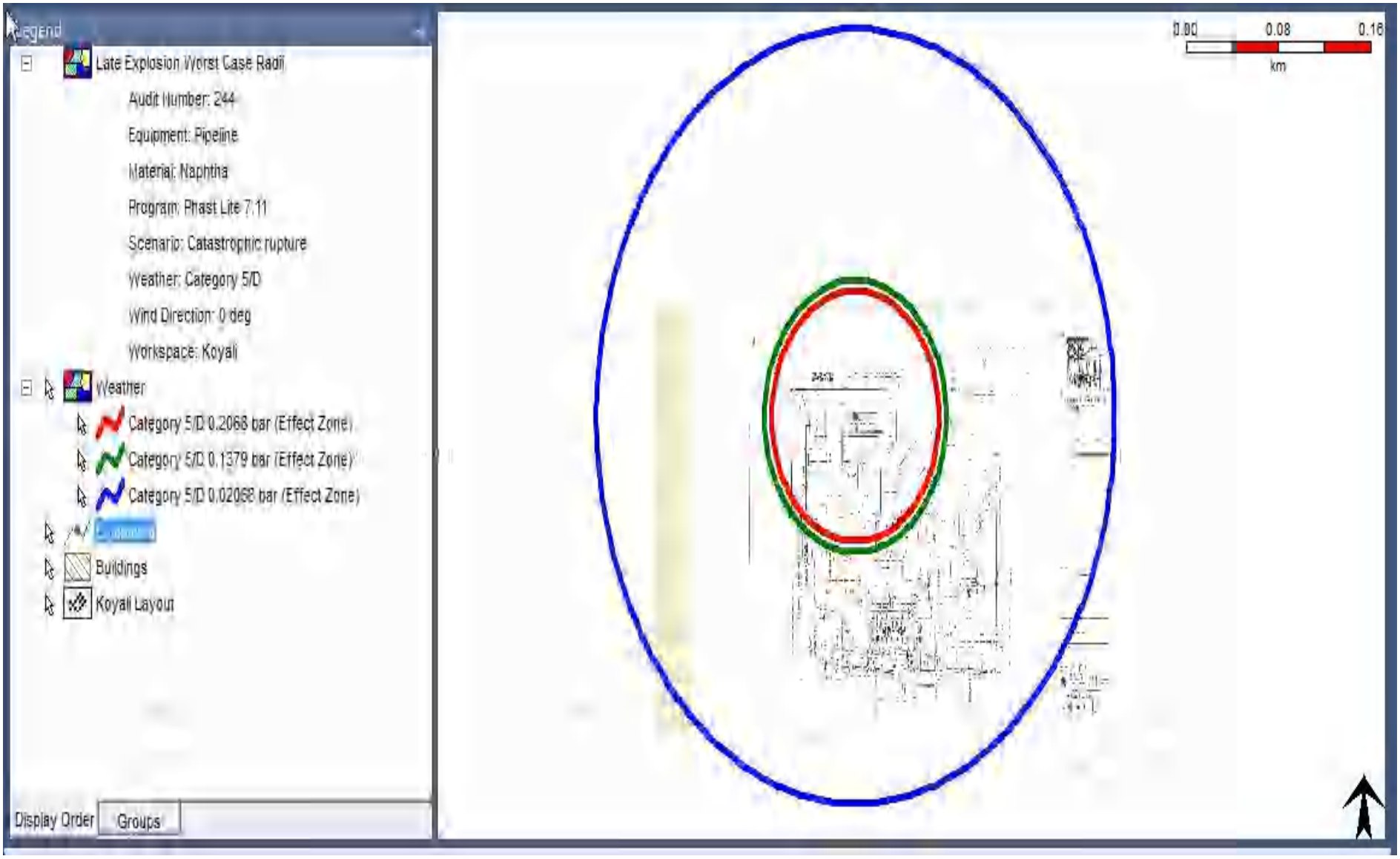


Figure 125:- Late Explosion Worst Case Radii of Koyali station (Rupture of pipeline)

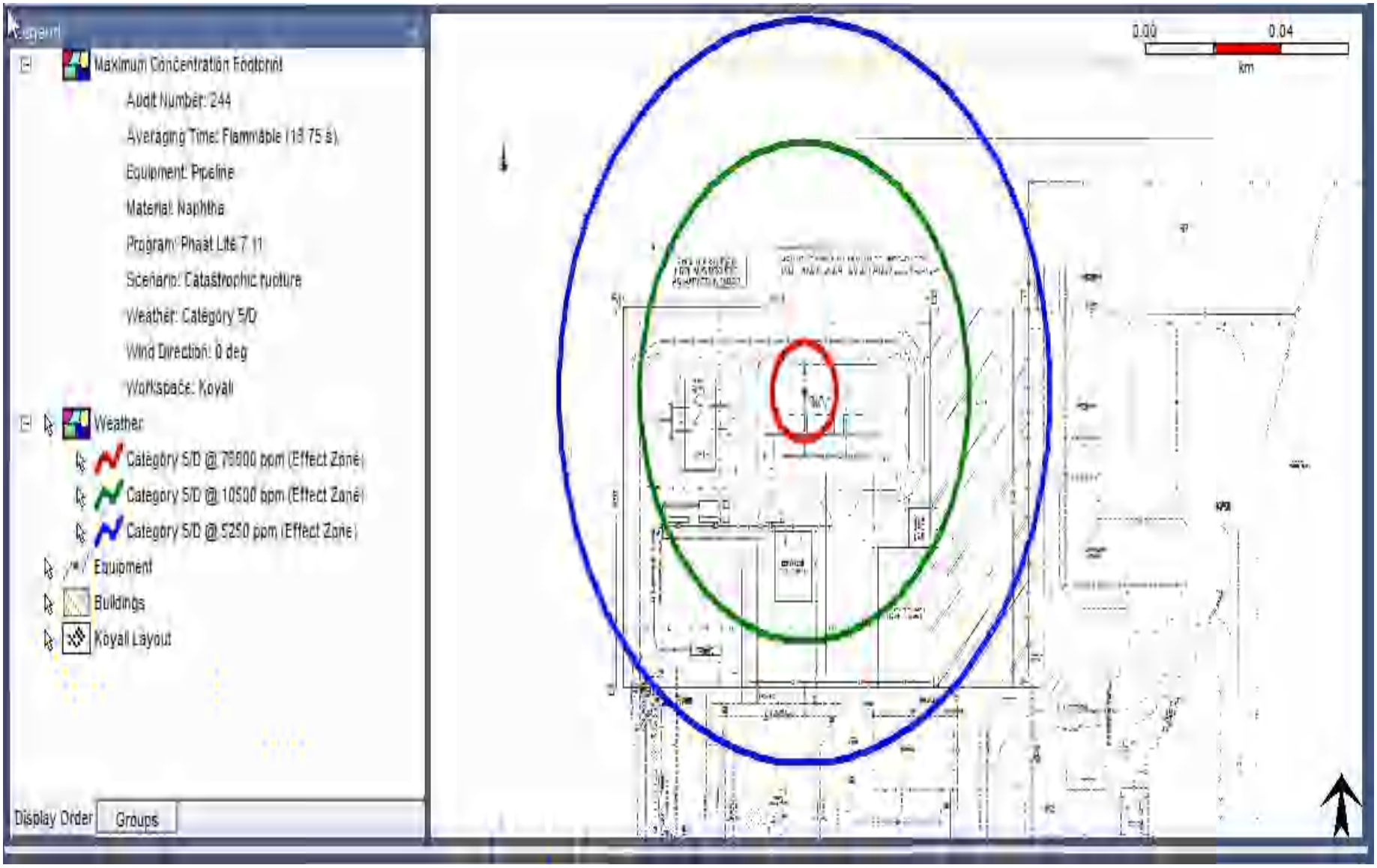


Figure 126:- Maximum Concentration Footprint of Koyali station (Rupture of pipeline)

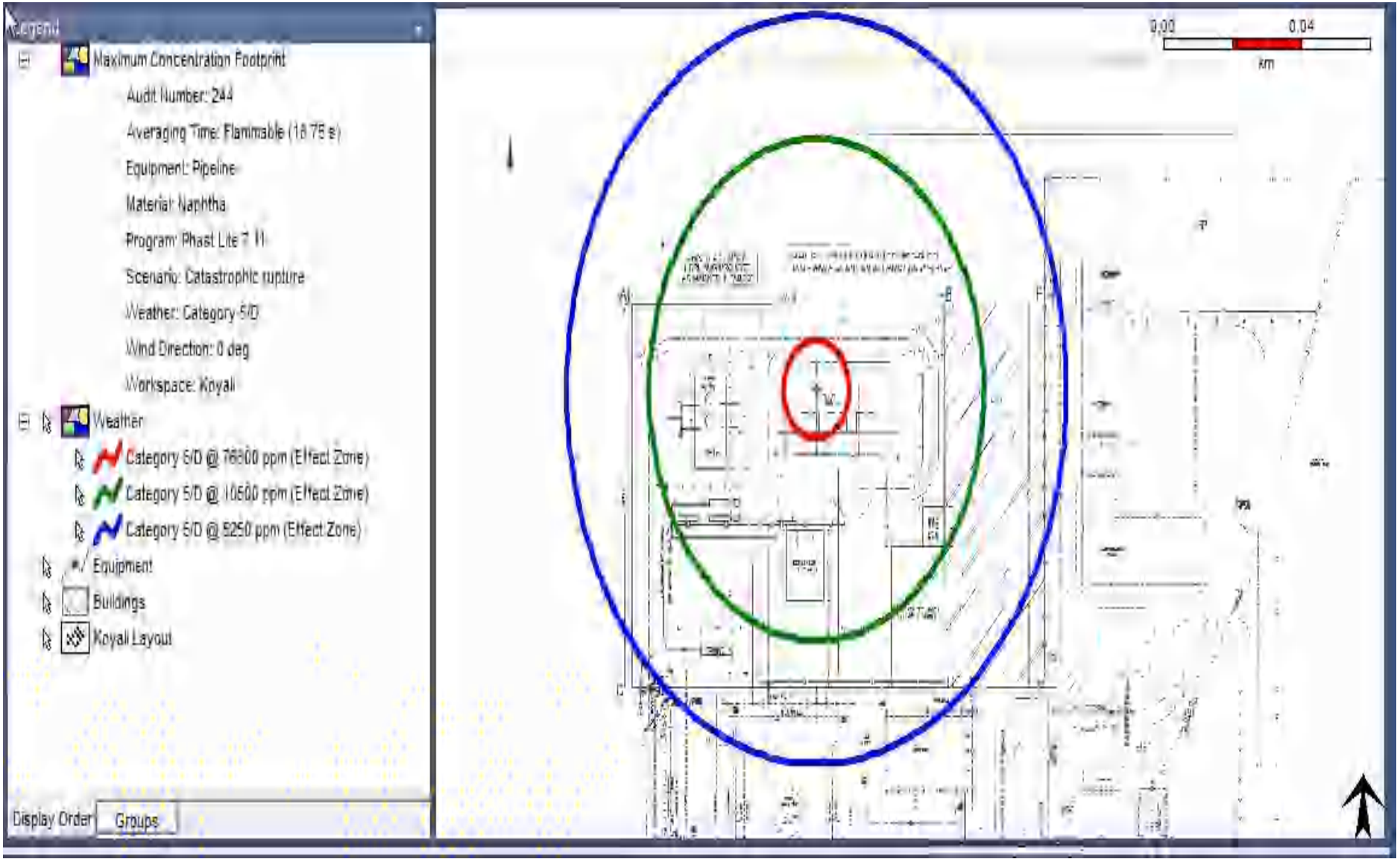


Figure 127:- Maximum Concentration Footprint of Koyali station (Rupture of pipeline)

ANNEXURE-B

MSDS- MOTOR SPIRIT (MS), HIGH SPEED DIESEL (HSD), SUPERIOR KEROSENE OIL (SKO)

Safety Data Sheet

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND COMPANY/UNDERTAKING

Material Name	:	**Gasoline**
Other Names / Synonyms	:	MOGAS, ULG 95, 88 RON, 90 RON, 91 RON, 92 RON, 93 RON, 95 RON, 97 UNLD, 91 UNLD
Recommended Use / Restrictions of Use	:	Fuel for spark ignition engines designed to run on unleaded fuel.
Supplier	:	**Shell Eastern Trading (PTE) Ltd** 9 North Buona Vista Drive, #07-01, Tower 1, The Metropolis Singapore 138588 Singapore
Telephone	:	+65-6384 8000
Emergency Telephone Number	:	+44 (0) 151 350 4595

2. HAZARDS IDENTIFICATION

GHS Classification	:	Flammable liquids, Category 1 Skin corrosion/irritation, Category 2 Aspiration hazard, Category 1 Toxic to reproduction, Category 2 Germ cell mutagenicity, Category 1B Carcinogenicity, Category 1B Specific target organ toxicity - single exposure, Category 3, Inhalation, Narcotic effects. Acute hazards to the aquatic environment, Category 2 Hazardous to the aquatic environment - Long-term Hazard, Category 2
GHS Label Elements **Symbol(s)**	:	
Signal Words	:	Danger
Hazard Statement	:	PHYSICAL HAZARDS:

H224: Extremely flammable liquid and vapour.

HEALTH HAZARDS:
H304: May be fatal if swallowed and enters airways.
H315: Causes skin irritation.
H336: May cause drowsiness or dizziness.
H340: May cause genetic defects.
H350: May cause cancer.
H361: Suspected of damaging fertility or the unborn child.

ENVIRONMENTAL HAZARDS:
H401: Toxic to aquatic life.
H411: Toxic to aquatic life with long lasting effects.

GHS Precautionary Statements

Prevention : P201: Obtain special instructions before use.
P210: Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
P280: Wear protective gloves/protective clothing/eye protection/face protection.

Response : P301+P310: IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician.

Storage : P403+P233: Store in a well-ventilated place. Keep container tightly closed.

Disposal: : P501: Dispose of contents and container to appropriate waste site or reclaimer in accordance with local and national regulations.

Other Hazards which do not result in classification : Liquid evaporates quickly and can ignite leading to a flash fire, or an explosion in a confined space. This material is a static accumulator. Even with proper grounding and bonding, this material can still accumulate an electrostatic charge. If sufficient charge is allowed to accumulate, electrostatic discharge and ignition of flammable air-vapour mixtures can occur.
Slightly irritating to respiratory system. This product contains benzene which may cause leukaemia (AML - acute myelogenous leukaemia). May cause MDS (Myelodysplastic Syndrome).

Additional Information : This product is intended for use in closed systems only.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Mixture Description : Complex mixture of hydrocarbons consisting of paraffins, cycloparaffins, aromatic and olefinic hydrocarbons with carbon numbers predominantly in the C4 to C12 range. Includes benzene at 0.1 - 5% v/v. Contains oxygenated hydrocarbons which may include methyl tertiary butyl ether (MTBE) and other ethers. May also contain several additives at <0.1% v/v each.

Synonyms : MOGAS, ULG 95, 88 RON, 90 RON, 91 RON, 92 RON, 93 RON, 95 RON, 97 UNLD, 91 UNLD

Classification of components according to GHS

Chemical Identity	Synonyms	CAS	Hazard Class (category)	Hazard Statement	Conc.
Gasoline, low boiling point naphtha	Gasoline, low boiling point naphtha	86290-81-5	Flam. Liq., 1; Skin Corr., 2; Asp. Tox., 1; Muta., 1B; Carc., 1B; STOT SE, 3; Aquatic Chronic, 2; Aquatic Acute, 2; Repr., 2;	H224; H315; H304; H340; H350; H336; H411; H401; H361;	85.00 - 100.00 %
Ethyl tertiary butyl ether	Ethyl tertiary butyl ether	637-92-3	Flam. Liq., 2; STOT SE, 3; Asp. Tox., 2; Aquatic Acute, 3;	H225; H336; H305; H402;	0.00 - 15.00 %
Methyl tertiary butyl ether	Methyl tertiary butyl ether	1634-04-4	Flam. Liq., 2; Skin Corr., 3; Acute Tox., 5; Asp. Tox., 2;	H225; H316; H303; H305;	0.00 - 15.00 %
Tertiary amyl methyl ether	Tertiary amyl methyl ether	994-05-8	Flam. Liq., 2; Acute Tox., 4; STOT SE, 3;	H225; H302; H336;	0.00 - 15.00 %

Additional Information : Contains Benzene, CAS # 71-43-2. Contains Toluene, CAS # 108-88-3. Contains Ethylbenzene, CAS # 100-41-4. Contains n-Hexane, CAS # 110-54-3. Contains Xylene (Mixed Isomers), CAS # 1330-20-7. Contains Cyclohexane, CAS# 110-82-7. Contains Cumene, CAS# 98-82-8 Contains Tri-methyl-benzene (all isomers), CAS# 25551-13-7.

Contains Naphthalene, CAS # 91-20-3.

The amount of oxygenated components is limited at 2.7 % m/m calculated as oxygen. Alcohols may be present at <0.1%v. Dyes and markers can be used to indicate tax status and prevent fraud. Refer to Ch 16 for full text of H phrases.

Refer to chapter 16 for full text of EC R-phrases.

4. FIRST-AID MEASURES

Inhalation	:	Remove to fresh air. If rapid recovery does not occur, transport to nearest medical facility for additional treatment.
Skin Contact	:	Remove contaminated clothing. Immediately flush skin with large amounts of water for at least 15 minutes, and follow by washing with soap and water if available. If redness, swelling, pain and/or blisters occur, transport to the nearest medical facility for additional treatment. When using high pressure equipment, injection of product under the skin can occur. If high pressure injuries occur, the casualty should be sent immediately to a hospital. Do not wait for symptoms to develop.
Eye Contact	:	Flush eyes with water while holding eyelids open. Rest eyes for 30 minutes. If redness, burning, blurred vision, or swelling persist transport to the nearest medical facility for additional treatment.
Ingestion	:	If swallowed, do not induce vomiting: transport to nearest medical facility for additional treatment. If vomiting occurs spontaneously, keep head below hips to prevent aspiration. If any of the following delayed signs and symptoms appear within the next 6 hours, transport to the nearest medical facility: fever greater than 101° F (38.3°C), shortness of breath, chest congestion or continued coughing or wheezing.
Most Important Symptoms/Effects, Acute & Delayed	:	Skin irritation signs and symptoms may include a burning sensation, redness, or swelling. Eye irritation signs and symptoms may include a burning sensation and a temporary redness of the eye. If material enters lungs, signs and symptoms may include coughing, choking, wheezing, difficulty in breathing, chest congestion, shortness of breath, and/or fever. The onset of respiratory symptoms may be delayed for several hours after exposure. Breathing of high vapour concentrations may cause central nervous system (CNS) depression resulting in dizziness, light-headedness, headache, nausea and loss of coordination. Continued inhalation may result in unconsciousness and death. Auditory system effects may include temporary hearing loss and/or ringing in the ears.

Immediate medical attention, special treatment	:	Treat symptomatically.

5. FIRE-FIGHTING MEASURES

Clear fire area of all non-emergency personnel.

Specific hazards arising from Chemicals	:	Hazardous combustion products may include: A complex mixture of airborne solid and liquid particulates and gases (smoke). Carbon monoxide may be evolved if incomplete combustion occurs. Unidentified organic and inorganic compounds. The vapour is heavier than air, spreads along the ground and distant ignition is possible. Will float and can be reignited on surface water.
Suitable Extinguishing Media	:	Foam, water spray or fog. Dry chemical powder, carbon dioxide, sand or earth may be used for small fires only.
Unsuitable Extinguishing Media	:	Do not use direct water jets on the burning product as they could cause a steam explosion and spread of the fire. Simultaneous use of foam and water on the same surface is to be avoided as water destroys the foam.
Protective Equipment & Precautions for Fire Fighters	:	Proper protective equipment including chemical resistant gloves are to be worn; chemical resistant suit is indicated if large contact with spilled product is expected. Self-Contained Breathing Apparatus must be worn when approaching a fire in a confined space. Select fire fighter's clothing approved to relevant Standards (e.g. Europe: EN469).
Additional Advice	:	Keep adjacent containers cool by spraying with water. If possible remove containers from the danger zone. If the fire cannot be extinguished the only course of action is to evacuate immediately. Contain residual material at affected sites to prevent material from entering drains (sewers), ditches, and waterways.

6. ACCIDENTAL RELEASE MEASURES

Avoid contact with skin, eyes and clothing. Evacuate the area of all non-essential personnel. Ventilate contaminated area thoroughly. If contamination of sites occurs remediation may require specialist advice. Avoid contact with spilled or released material. Immediately remove all contaminated clothing. For guidance on selection of personal protective equipment see Chapter 8 of this Material Safety Data Sheet. For guidance on disposal of spilled material see Chapter 13 of this Material Safety Data Sheet. Ensure electrical continuity by bonding and grounding (earthing) all equipment. Observe the relevant local and international regulations. Take precautionary measures against static discharges.

Personal Precautions, Protective Equipment and Emergency Procedures	:	Do not breathe fumes, vapour. Do not operate electrical equipment. Shut off leaks, if possible without personal risks. Remove all possible sources of ignition in the surrounding area. Vapour can travel for considerable distances both above and below the ground surface. Underground services (drains, pipelines, cable ducts) can provide preferential flow paths. Evacuate all personnel. Attempt to disperse vapour or to direct its flow to a safe location for example using fog sprays.
Environmental Precautions	:	Take measures to minimise the effects on groundwater. Contain residual material at affected sites to prevent material from entering drains (sewers), ditches, and waterways. Prevent from spreading or entering into drains, ditches or rivers by using sand, earth, or other appropriate barriers.
Methods and Material for Containment and Cleaning Up	:	Take precautionary measures against static discharges. For large liquid spills (> 1 drum), transfer by mechanical means such as vacuum truck to a salvage tank for recovery or safe disposal. Do not flush away residues with water. Retain as contaminated waste. Allow residues to evaporate or soak up with an appropriate absorbent material and dispose of safely. Remove contaminated soil and dispose of safely. For small liquid spills (< 1 drum), transfer by mechanical means to a labelled, sealable container for product recovery or safe disposal. Allow residues to evaporate or soak up with an appropriate absorbent material and dispose of safely. Remove contaminated soil and dispose of safely.
Additional Advice	:	Notify authorities if any exposure to the general public or the environment occurs or is likely to occur. Local authorities should be advised if significant spillages cannot be contained. Maritime spillages should be dealt with using a Shipboard Oil Pollution Emergency Plan (SOPEP), as required by MARPOL Annex 1 Regulation 26. To the extent that this product, including its chemical components (e.g. methyl tertiary butyl ether) may impact surface or groundwater, appropriate assessment and remediation (if necessary) should be implemented.

7. HANDLING AND STORAGE

General Precautions	:	Avoid breathing vapours or contact with material. Only use in well ventilated areas. Wash thoroughly after handling. For guidance on selection of personal protective equipment see Chapter 8 of this Material Safety Data Sheet. Use the information in this data sheet as input to a risk assessment of local circumstances to help determine appropriate controls for

		safe handling, storage and disposal of this material. Air-dry contaminated clothing in a well-ventilated area before laundering. Prevent spillages. Turn off all battery operated portable electronic devices (examples include: cellular phones, pagers and CD players) before operating gasoline pump. Contaminated leather articles including shoes cannot be decontaminated and should be destroyed to prevent reuse. Do not use as a cleaning solvent or other non-motor fuel uses. Vehicle fueling and vehicle workshop areas - Avoid inhalation of vapours and contact with skin, when filling or emptying a vehicle.
Precautions for Safe Handling	:	When using do not eat or drink. Extinguish any naked flames. Do not smoke. Remove ignition sources. Avoid sparks. Never siphon by mouth. The vapour is heavier than air, spreads along the ground and distant ignition is possible. Avoid exposure. Use local exhaust ventilation if there is risk of inhalation of vapours, mists or aerosols. Properly dispose of any contaminated rags or cleaning materials in order to prevent fires.
Conditions for Safe Storage	:	Drum and small container storage: Keep containers closed when not in use. Drums should be stacked to a maximum of 3 high. Use properly labelled and closeable containers. Packaged product must be kept tightly closed and stored in a diked (bunded) well-ventilated area, away from, ignition sources and other sources of heat. Take suitable precautions when opening sealed containers, as pressure can build up during storage. Tank storage: Tanks must be specifically designed for use with this product. Bulk storage tanks should be diked (bunded). Locate tanks away from heat and other sources of ignition. Cleaning, inspection and maintenance of storage tanks is a specialist operation, which requires the implementation of strict procedures and precautions. Keep in a cool place. Electrostatic charges will be generated during pumping. Electrostatic discharge may cause fire. Ensure electrical continuity by bonding and grounding (earthing) all equipment to reduce the risk. The vapours in the head space of the storage vessel may lie in the flammable/explosive range and hence may be flammable. Refer to section 15 for any additional specific legislation covering the packaging and storage of this product.
Product Transfer	:	Wait 2 minutes after tank filling (for tanks such as those on road tanker vehicles) before opening hatches or manholes. Wait 30 minutes after tank filling (for large storage tanks) before opening hatches or manholes. Even with proper grounding and bonding, this material can still accumulate an electrostatic charge. If sufficient charge is allowed to

		accumulate, electrostatic discharge and ignition of flammable air-vapour mixtures can occur. Be aware of handling operations that may give rise to additional hazards that result from the accumulation of static charges. These include but are not limited to pumping (especially turbulent flow), mixing, filtering, splash filling, cleaning and filling of tanks and containers, sampling, switch loading, gauging, vacuum truck operations, and mechanical movements. These activities may lead to static discharge e.g. spark formation. Restrict line velocity during pumping in order to avoid generation of electrostatic discharge (<= 1 m/s until fill pipe submerged to twice its diameter, then <= 7 m/s). Avoid splash filling. Do NOT use compressed air for filling, discharging, or handling operations.
Recommended Materials	:	For containers, or container linings use mild steel, stainless steel. Aluminium may also be used for applications where it does not present an unnecessary fire hazard. Examples of suitable materials are: high density polyethylene (HDPE), polypropylene (PP), and Viton (FKM), which have been specifically tested for compatibility with this product. For container linings, use amine-adduct cured epoxy paint. For seals and gaskets use: graphite, PTFE, Viton A, Viton B.
Unsuitable Materials	:	Some synthetic materials may be unsuitable for containers or container linings depending on the material specification and intended use. Examples of materials to avoid are: natural rubber (NR), nitrile rubber (NBR), ethylene propylene rubber (EPDM), polymethyl methacrylate (PMMA), polystyrene, polyvinyl chloride (PVC), polyisobutylene. However, some may be suitable for glove materials.
Container Advice	:	Containers, even those that have been emptied, can contain explosive vapours. Do not cut, drill, grind, weld or perform similar operations on or near containers. Gasoline containers must not be used for storage of other products.
Other Advice	:	Ensure that all local regulations regarding handling and storage facilities are followed. See additional references that provide safe handling practices for liquids that are determined to be static accumulators: American Petroleum Institute 2003 (Protection Against Ignitions Arising out of Static, Lightning and Stray Currents) or National Fire Protection Agency 77 (Recommended Practices on Static Electricity). CENELEC CLC/TR 50404 (Electrostatics – Code of practice for the avoidance of hazards due to static electricity).

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

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If the American Conference of Governmental Industrial Hygienists (ACGIH) value is provided on this document, it is provided for information only.

Occupational Exposure Limits

Material	Source	Type	ppm	mg/m3	Notation
Gasoline, low boiling point naphtha	ACGIH	TWA	300 ppm		
	ACGIH	STEL	500 ppm		
	SG OEL	TWA	300 ppm	890 mg/m3	
	SG OEL	STEL	500 ppm	1,480 mg/m3	
Trimethylbenzene, all isomers	ACGIH	TWA	25 ppm		
	SG OEL	TWA	25 ppm	123 mg/m3	
Ethylbenzene	ACGIH	TWA	20 ppm		
	SG OEL	TWA	100 ppm	434 mg/m3	
	SG OEL	STEL	125 ppm	543 mg/m3	
n-hexane	ACGIH	TWA	50 ppm		
	ACGIH	SKIN_DES			Can be absorbed through the skin.
	SG OEL	TWA	50 ppm	176 mg/m3	
Benzene	ACGIH	TWA	0.5 ppm		
	ACGIH	STEL	2.5 ppm		
	ACGIH	SKIN_DES			Can be absorbed through the skin.
	SG OEL	TWA	1 ppm	3.18 mg/m3	

	SHELL IS	TWA	0.5 ppm	1.6 mg/m3	
	SHELL IS	STEL	2.5 ppm	8 mg/m3	
Toluene	ACGIH	TWA	20 ppm		
	SG OEL	TWA	50 ppm	188 mg/m3	
Xylene	ACGIH	TWA	100 ppm		
	ACGIH	STEL	150 ppm		
	SG OEL	TWA	100 ppm	434 mg/m3	
	SG OEL	STEL	150 ppm	651 mg/m3	
Cyclohexane	ACGIH	TWA	100 ppm		
	SG OEL	TWA	300 ppm	1,030 mg/m3	
Naphthalene	ACGIH	TWA	10 ppm		
	ACGIH	STEL	15 ppm		
	ACGIH	SKIN_DES			Can be absorbed through the skin.
	SG OEL	TWA	10 ppm	52 mg/m3	
	SG OEL	STEL	15 ppm	79 mg/m3	
Ethyl tertiary butyl ether	ACGIH	TWA	25 ppm		
Methyl tertiary butyl ether	ACGIH	TWA	50 ppm		
	SG OEL	TWA	40 ppm	144 mg/m3	
Tertiary amyl methyl ether	ACGIH	TWA	20 ppm		
Cumene	ACGIH	TWA	50 ppm		
	SG OEL	TWA	50 ppm	246 mg/m3	

Additional Information : SHELL IS is the Shell Internal Standard. Skin notation means that significant exposure can also occur by absorption of liquid through the skin and of vapour through the eyes or mucous membranes.

Biological Exposure Index (BEI)

Material	Determinant	Sampling Time	BEI	Reference
Benzene	t,t-Muconic acid in Creatinine in urine	Sampling time: End of shift.	500 µg/g	ACGIH BEL (2011)
	S-Phenylmercapturic acid in Creatinine in urine	Sampling time: End of shift.	25 µg/g	ACGIH BEL (2011)
n-hexane	2,5-Hexanedion, without hydrolysis in Urine	Sampling time: End of shift at end of work week.	0.4 mg/l	ACGIH BEL (2011)
Toluene	o-Cresol, with hydrolysis in Creatinine in urine	Sampling time: End of shift.	0.3 mg/g	ACGIH BEL (2011)
	toluene in Blood	Sampling time: Prior to last shift of work week.	0.02 mg/l	ACGIH BEL (2011)
	toluene in Urine	Sampling time: End of shift.	0.03 mg/l	ACGIH BEL (2011)

Ethylbenzene	Sum of mandelic acid and phenylglyoxylic acid in Creatinine in urine	Sampling time: End of shift at end of work week.	0.7 g/g	ACGIH BEL (2011)
	Ethyl benzene in End-exhaled air	Sampling time: Not critical.		ACGIH BEL (2011)
Xylene	Methylhippuric acids in Creatinine in urine	Sampling time: End of shift.	1.5 g/g	ACGIH BEL (2011)
Naphthalene	1-Naphthol, with hydrolysis + 2-Naphthol, with hydrolysis	Sampling time: End of shift.		ACGIH BEL (02 2013)

Appropriate Engineering Controls : The level of protection and types of controls necessary will vary depending upon potential exposure conditions. Select controls based on a risk assessment of local circumstances. Appropriate measures include: Use sealed systems as far as possible. Adequate explosion-proof ventilation to control airborne concentrations below the exposure guidelines/limits. Local exhaust ventilation is recommended. Eye washes and showers for emergency use. Always observe good personal hygiene measures, such as washing hands after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants. Discard contaminated clothing and footwear that cannot be cleaned. Practice good housekeeping. Define procedures for safe handling and maintenance of controls. Educate and train workers in the hazards and control measures relevant to normal activities associated with this product. Ensure appropriate selection, testing and maintenance of equipment used to control exposure, e.g. personal protective equipment, local exhaust ventilation. Firewater monitors and deluge systems are recommended. Drain down system prior to equipment break-in or maintenance. Retain drain downs in sealed storage pending disposal or for subsequent recycle.

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Individual Protection Measures	:	Personal protective equipment (PPE) should meet recommended national standards. Check with PPE suppliers.
Respiratory Protection	:	If engineering controls do not maintain airborne concentrations to a level which is adequate to protect worker health, select respiratory protection equipment suitable for the specific conditions of use and meeting relevant legislation. Check with respiratory protective equipment suppliers. Where air-filtering respirators are suitable, select an appropriate combination of mask and filter. Where air-filtering respirators are unsuitable (e.g. airborne concentrations are high, risk of oxygen deficiency, confined space) use appropriate positive pressure breathing apparatus. All respiratory protection equipment and use must be in accordance with local regulations. Select a filter suitable for combined particulate/organic gases and vapours [boiling point >65°C(149 °F)].
Hand Protection	:	Personal hygiene is a key element of effective hand care. Gloves must only be worn on clean hands. After using gloves, hands should be washed and dried thoroughly. Application of a non-perfumed moisturizer is recommended. Suitability and durability of a glove is dependent on usage, e.g. frequency and duration of contact, chemical resistance of glove material, dexterity. Always seek advice from glove suppliers. Contaminated gloves should be replaced. For continuous contact we recommend gloves with breakthrough time of more than 240 minutes with preference for > 480 minutes where suitable gloves can be identified. For short-term/splash protection we recommend the same, but recognise that suitable gloves offering this level of protection may not be available and in this case a lower breakthrough time may be acceptable so long as appropriate maintenance and replacement regimes are followed. Glove thickness is not a good predictor of glove resistance to a chemical as it is dependent on the exact composition of the glove material. Select gloves tested to a relevant standard (e.g. Europe EN374, US F739). When prolonged or frequent repeated contact occurs, Nitrile gloves may be suitable. (Breakthrough time of > 240 minutes.) For incidental contact/splash protection Neoprene, PVC gloves may be suitable.
Eye Protection	:	Chemical splash goggles (chemical monogoggles). If a local risk assessment deems it so, then chemical splash goggles may not be required and safety glasses may provide adequate eye protection.
Protective Clothing	:	Chemical resistant gloves/gauntlets, boots, and apron (where risk of splashing).
Thermal Hazards	:	Not applicable.

Monitoring Methods	:	Monitoring of the concentration of substances in the breathing zone of workers or in the general workplace may be required to confirm compliance with an OEL and adequacy of exposure controls. For some substances biological monitoring may also be appropriate. Validated exposure measurement methods should be applied by a competent person and samples analysed by an accredited laboratory. Examples of sources of recommended exposure measurement methods are given below or contact the supplier. Further national methods may be available. National Institute of Occupational Safety and Health (NIOSH), USA: Manual of Analytical Methods http://www.cdc.gov/niosh/ Occupational Safety and Health Administration (OSHA), USA: Sampling and Analytical Methods http://www.osha.gov/
Environmental Exposure Controls	:	Local guidelines on emission limits for volatile substances must be observed for the discharge of exhaust air containing vapour. Take appropriate measures to fulfil the requirements of relevant environmental protection legislation. Avoid contamination of the environment by following advice given in Chapter 6. If necessary, prevent undissolved material from being discharged to waste water. Waste water should be treated in a municipal or industrial waste water treatment plant before discharge to surface water.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	:	Yellow. Clear, bright liquid.
Odour	:	Hydrocarbon
Odour threshold	:	Data not available
pH	:	Data not available
Initial Boiling Point and Boiling Range	:	25 - 220 °C / 77 - 428 °F
Freezing Point	:	Data not available
Flash point	:	-40 °C / -40 °F (Tagliabue Closed Cup)
Upper / lower Flammability or Explosion limits	:	1 - 8 %(V)
Auto-ignition temperature	:	> 250 °C / 482 °F
Vapour pressure	:	Typical 570 hPa at 37.8 °C / 100.0 °F
Relative Density	:	Data not available
Density	:	Typical 0.740 g/cm3 at 15 °C / 59 °F
Water solubility	:	Negligible.
Solubility in other solvents	:	Data not available
n-octanol/water partition	:	2 - 7

coefficient (log Pow)		
Dynamic viscosity	:	Data not available
Kinematic viscosity	:	0.5 - 0.75 mm2/s at 40 °C / 104 °F
Vapour density (air=1)	:	Data not available
Electrical conductivity	:	Low conductivity: < 100 pS/m, The conductivity of this material makes it a static accumulator., A liquid is typically considered nonconductive if its conductivity is below 100 pS/m and is considered semi-conductive if its conductivity is below 10 000 pS/m., Whether a liquid is nonconductive or semi-conductive, the precautions are the same., A number of factors, for example liquid temperature, presence of contaminants, and anti-static additives can greatly influence the conductivity of a liquid.
Evaporation rate (nBuAc=1)	:	Data not available
Decomposition Temperature	:	Data not available
Flammability	:	Extremely flammable.

10. STABILITY AND REACTIVITY

Chemical stability	:	Stable under normal conditions of use.
Possibility of Hazardous Reactions	:	No hazardous reaction is expected when handled and stored according to provisions.
Conditions to Avoid	:	Avoid heat, sparks, open flames and other ignition sources.
Incompatible Materials	:	Strong oxidising agents.
Hazardous Decomposition Products	:	Hazardous decomposition products are not expected to form during normal storage. Thermal decomposition is highly dependent on conditions. A complex mixture of airborne solids, liquids and gases, including carbon monoxide, carbon dioxide and other organic compounds will be evolved when this material undergoes combustion or thermal or oxidative degradation.
Hazardous Polymerisation	:	No
Sensitivity to Mechanical Impact	:	No
Sensitivity to Static Discharge	:	Yes, in certain circumstances product can ignite due to static electricity.

11. TOXICOLOGICAL INFORMATION

Information on Toxicological effects

Basis for Assessment	:	Information given is based on product data, a knowledge of the components and the toxicology of similar products. Unless indicated otherwise, the data presented is representative of the

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product as a whole, rather than for individual component(s).

Likely Routes of Exposure	:	Exposure may occur via inhalation, ingestion, skin absorption, skin or eye contact, and accidental ingestion.
Acute Oral Toxicity	:	Low toxicity: LD50 > 5000 mg/kg
Acute Dermal Toxicity	:	Low toxicity: LD50 >2000 mg/kg , Rabbit
Acute Inhalation Toxicity	:	Low toxicity: LC50 >5 mg/l , 4 h, Rat
Skin corrosion/irritation	:	Irritating to skin.
Serious eye damage/irritation	:	Expected to be slightly irritating.
Respiratory Irritation	:	Based on human experience, breathing of vapours or mists may cause a temporary burning sensation to nose, throat and lungs.
Respiratory or skin sensitisation	:	Not expected to be a sensitiser.
Aspiration Hazard	:	Aspiration into the lungs when swallowed or vomited may cause chemical pneumonitis which can be fatal.
Germ cell mutagenicity	:	May cause heritable genetic damage. (Benzene) Mutagenicity studies on gasoline and gasoline blending streams have shown predominantly negative results.
Carcinogenicity	:	Known human carcinogen. (Benzene) May cause leukaemia (AML - acute myelogenous leukemia). (Benzene) Inhalation exposure to mice causes liver tumours, which are not considered relevant to humans.

Material	:	**Carcinogenicity Classification**
Gasoline, low boiling point naphtha	:	ACGIH Group A3: Confirmed animal carcinogen with unknown relevance to humans.
Gasoline, low boiling point naphtha	:	IARC 2B: Possibly carcinogenic to humans.
Gasoline, low boiling point naphtha	:	GHS / CLP: Carcinogenicity Category 1B
Trimethylbenzene, all isomers	:	GHS / CLP: No carcinogenicity classification
Ethylbenzene	:	IARC 2B: Possibly carcinogenic to humans.
Ethylbenzene	:	GHS / CLP: No carcinogenicity classification
n-hexane	:	GHS / CLP: No carcinogenicity classification

Benzene	:	ACGIH Group A1: Confirmed human carcinogen.
Benzene	:	NTP: Known To Be Human Carcinogen.
Benzene	:	IARC 1: Carcinogenic to humans.
Benzene	:	GHS / CLP: Carcinogenicity Category 1A
Toluene	:	ACGIH Group A4: Not classifiable as a human carcinogen.
Toluene	:	IARC 3: Not classifiable as to carcinogenicity to humans.
Toluene	:	GHS / CLP: No carcinogenicity classification
Xylene	:	ACGIH Group A4: Not classifiable as a human carcinogen.
Xylene	:	IARC 3: Not classifiable as to carcinogenicity to humans.
Xylene	:	GHS / CLP: No carcinogenicity classification
Cyclohexane	:	GHS / CLP: No carcinogenicity classification
Naphthalene	:	ACGIH Group A4: Not classifiable as a human carcinogen.
Naphthalene	:	NTP: Reasonably Anticipated to be a Human Carcinogen.
Naphthalene	:	IARC 2B: Possibly carcinogenic to humans.
Naphthalene	:	GHS / CLP: Carcinogenicity Category 2
Ethyl tertiary butyl ether	:	ACGIH Group A4: Not classifiable as a human carcinogen.
Ethyl tertiary butyl ether	:	GHS / CLP: No carcinogenicity classification
Methyl tertiary butyl ether	:	IARC 3: Not classifiable as to carcinogenicity to humans.
Methyl tertiary butyl ether	:	GHS / CLP: No carcinogenicity classification
Tertiary amyl methyl ether	:	GHS / CLP: No carcinogenicity classification
Cumene	:	IARC 2B: Possibly carcinogenic to humans.
Cumene	:	GHS / CLP: No carcinogenicity classification

Reproductive and Developmental Toxicity : Causes foetotoxicity at doses which are maternally toxic. (Toluene)
May impair fertility at doses which produce other toxic effects. (n-hexane)
Many case studies involving abuse during pregnancy indicate that toluene can cause birth defects, growth retardation and learning difficulties. (Toluene)
Inhalation of high concentrations of gasoline vapour containing Methyl tertiary butyl ether produced a very low incidence of rare birth defects (ventral midline closure failure) in mice.

Specific target organ toxicity - single exposure : High concentrations may cause central nervous system depression resulting in headaches, dizziness and nausea; continued inhalation may result in unconsciousness and/or death.

Specific target organ toxicity - repeated exposure : Kidney: caused kidney effects in male rats which are not considered relevant to humans

Blood-forming organs: repeated exposure affects the bone

marrow.

Additional Information : Prolonged and repeated exposures to high concentrations have resulted in hearing loss in rats. Solvent abuse and noise interaction in the work environment may cause hearing loss. (Toluene)

Abuse of vapours has been associated with organ damage and death. (Toluene)

Exposure to very high concentrations of similar materials has been associated with irregular heart rhythms and cardiac arrest.

May cause MDS (Myelodysplastic Syndrome). (Benzene)

Classifications by other authorities under varying regulatory frameworks may exist.

12. ECOLOGICAL INFORMATION

Basis for Assessment : Fuels are typically made from blending several refinery streams. Ecotoxicological studies have been carried out on a variety of hydrocarbon blends and streams but not those containing additives. Information given is based on a knowledge of the components and the ecotoxicology of similar products. Unless indicated otherwise, the data presented is representative of the product as a whole, rather than for individual component(s).

Acute Toxicity : Expected to be toxic: LL/EL/IL50 > 1 <= 10 mg/l (to aquatic organisms) LL/EL50 expressed as the nominal amount of product required to prepare aqueous test extract.

Fish : Expected to be toxic: LL/EL/IL50 > 1 <= 10 mg/l

Aquatic crustacea : Expected to be toxic: LL/EL/IL50 > 1 <= 10 mg/l

Algae/aquatic plants : Expected to be toxic: LL/EL/IL50 > 1 <= 10 mg/l

Microorganisms : Expected to be harmful: LL/EL/IL50 >10 <= 100 mg/l

Chronic Toxicity

Fish : NOEC/NOEL expected to be > 1.0 - <= 10 mg/l

Aquatic crustacea : NOEC/NOEL expected to be > 1.0 - <= 10 mg/l

Mobility : Evaporates within a day from water or soil surfaces. Large volumes may penetrate soil and could contaminate groundwater. Toxic to aquatic organisms; may cause long-term adverse effects in the aquatic environment. Ether oxygenates are significantly more water soluble and less biodegradable

		than benzene, toluene, ethyl benzene and xylenes (BTEX). Consequently ether oxygenates have the potential to migrate relatively longer distances than BTEX in groundwater. Contains volatile components. Floats on water. Methyl tertiary butyl ether degradation may result in the formation of tert-butyl alcohol (TBA).
Persistence/degradability	:	Major constituents are expected to be inherently biodegradable, but the product contains components that may persist in the environment. The volatile constituents will oxidize rapidly by photochemical reactions in air. While biodegradation of Methyl tertiary butyl ether has been documented, it is generally less biodegradable than many petroleum hydrocarbons and has a potential to migrate relatively longer distances in groundwater.
Bioaccumulative Potential	:	Contains constituents with the potential to bioaccumulate. Log Kow > =4
Other Adverse Effects	:	Films formed on water may affect oxygen transfer and damage organisms.

13. DISPOSAL CONSIDERATIONS

Material Disposal	:	Recover or recycle if possible. It is the responsibility of the waste generator to determine the toxicity and physical properties of the material generated to determine the proper waste classification and disposal methods in compliance with applicable regulations. Waste arising from a spillage or tank cleaning should be disposed of in accordance with prevailing regulations, preferably to a recognised collector or contractor. The competence of the collector or contractor should be established beforehand. Do not dispose into the environment, in drains or in water courses. Do not dispose of tank water bottoms by allowing them to drain into the ground. This will result in soil and groundwater contamination.
Container Disposal	:	Drain container thoroughly. After draining, vent in a safe place away from sparks and fire. Residues may cause an explosion hazard. Do not puncture, cut, or weld uncleaned drums. Send to drum recoverer or metal reclaimer. Do not pollute the soil, water or environment with the waste container.
Local Legislation	:	Disposal should be in accordance with applicable regional, national, and local laws and regulations. Local regulations may be more stringent than regional or national requirements and must be in compliance.

14. TRANSPORT INFORMATION

Land (as per ADR classification): Regulated

Class	:	3
Packing group	:	II
Hazard indentification no.	:	33
UN number	:	1203
Danger label (primary risk)	:	3
Proper shipping name	:	GASOLINE (UNLEADED)
Environmentally Hazardous	:	Yes

IMDG

Identification number	UN 1203
Proper shipping name	GASOLINE
Technical name	(UNLEADED)
Class / Division	3
Packing group	II
Environmental hazards:	Yes

IATA (Country variations may apply)

UN number	:	1203
Proper shipping name	:	Gasoline
Technical name	:	(UNLEADED)
Class / Division	:	3
Packing group	:	II

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code

Pollution Category	**:**	Not applicable.
Ship Type	**:**	Not applicable.
Product Name	**:**	Not applicable.
Special Precaution	**:**	Not applicable.
Additional Information	**:**	MARPOL Annex 1 rules apply for bulk shipments by sea.

15. REGULATORY INFORMATION

The regulatory information is not intended to be comprehensive. Other regulations may apply to this material.

Local Regulations

Workplace Safety and Health Act & Workplace	:	This product is subject to the requirement in the Act/ Regulations.

Safety and Health (General Provision) Regulations		
Environmental Protection and Management Act and Environmental Protection and Management (Hazardous Substances) Regulations	:	This product is subject to the requirement in the Act/ Regulations.
Maritime and Port Authority of Singapore (Dangerous Goods, Petroleum and Explosives) Regulations	:	This product is subject to the requirement in the Act/ Regulations.
Fire Safety Act and Fire Safety (Petroleum & Flammable Materials) Regulations	:	This product is subject to the requirement in the Act/ Regulations.
Classification triggering components	:	Contains gasoline, low boiling point naphtha, unspecified.

16. OTHER INFORMATION

Hazard Statement

H224	Extremely flammable liquid and vapour.
H225	Highly flammable liquid and vapour.
H302	Harmful if swallowed.
H303	May be harmful if swallowed.
H304	May be fatal if swallowed and enters airways.
H305	May be harmful if swallowed and enters airways.
H315	Causes skin irritation.
H316	Causes mild skin irritation.
H336	May cause drowsiness or dizziness.
H340	May cause genetic defects.
H350	May cause cancer.
H361	Suspected of damaging fertility or the unborn child.
H401	Toxic to aquatic life.
H402	Harmful to aquatic life.
H411	Toxic to aquatic life with long lasting effects.

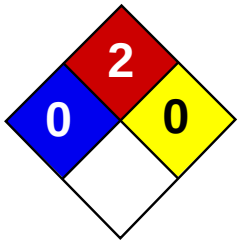
Additional Information	:	This document contains important information to ensure the safe storage, handling and use of this product. The information in this document should be brought to the attention of the person in your organisation responsible for advising on safety matters.
SDS Version Number	:	1.0
SDS Effective Date	:	10.03.2014

Safety Data Sheet

SDS Revisions	:	A vertical bar (|) in the left margin indicates an amendment from the previous version.
Uses and Restrictions	:	This product must not be used in applications other than those recommended in Section 1, without first seeking the advice of the supplier. This product is not to be used as a solvent or cleaning agent; for lighting or brightening fires; as a skin cleanser. This product is designed only to suit automotive applications and no provision is made for the requirements of aviation applications.
SDS Distribution	:	The information in this document should be made available to all who may handle the product.
Key/Legend to Abbrevations used in this SDS	:	The standard abbreviations and acronyms used in this document can be looked up in reference literature (e.g. scientific dictionaries) and/or websites.

Flam. Liq.	Flammable liquids
Asp. Tox.	Aspiration hazard
Muta.	Germ cell mutagenicity
Carc.	Carcinogenicity
Skin Corr.	Skin corrosion/irritation
STOT SE	Specific target organ toxicity - single exposure
	Toxic for Reproduction

Key Literature References	:	The quoted data are from, but not limited to, one or more sources of information (e.g. toxicological data from Shell Health Services, material suppliers' data, CONCAWE, EU IUCLID date base, EC 1272 regulation, etc).
Disclaimer	:	This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not therefore be construed as guaranteeing any specific property of the product.



Material Safety Data Sheet
Kerosene MSDS

Section 1: Chemical Product and Company Identification

Product Name: Kerosene

Catalog Codes: SLK1048

CAS#: 8008-20-6 or 64742-81-0

RTECS: OA5500000

TSCA: TSCA 8(b) inventory: Kerosene

CI#: Not available.

Synonym: Astral Oil; Coal Oil, Fuel Oil No. 5, Deobase, Astral Oil, Jet A Fuel; Jet Fuel JP-1; JP-5 Navy Fuel; Kerosine, petroleum; Range Oil; K1 Kerosene; Kerosene, hydrodesulfurized; Kerosine

Chemical Name: Kerosene

Chemical Formula: Not available.

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Kerosene	8008-20-6 or	100
	64742-81-0	

Toxicological Data on Ingredients: Kerosene: ORAL (LD50): Acute: 15000 mg/kg [Rat]. 20000 mg/kg [Guinea pig]. 2835 mg/kg [Rabbit].

Section 3: Hazards Identification

Potential Acute Health Effects:
Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (permeator). Severe over-exposure can result in death.

Potential Chronic Health Effects:
Slightly hazardous in case of skin contact (sensitizer). CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Mutagenic for bacteria and/or yeast. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance is toxic to the nervous system. The substance may be toxic to blood, kidneys, liver, central nervous system (CNS). Repeated or prolonged exposure to the substance can produce target organs damage. Repeated exposure to a highly toxic material may produce general deterioration of health by an accumulation in one or many human organs.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

Skin Contact:
In case of contact, immediately flush skin with plenty of water. Cover the irritated skin with an emollient. Remove contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Serious Inhalation:
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. WARNING: It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive. Seek immediate medical attention.

Ingestion:
If swallowed, do NOT induce vomiting. If swallowed, do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Flammable.

Auto-Ignition Temperature: 210°C (410°F)

Flash Points: CLOSED CUP: 38°C (100.4°F). (Tagliabue.)

Flammable Limits: LOWER: 0.7% UPPER: 5% - 7%

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: Flammable in presence of open flames and sparks, of heat.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
Flammable liquid, insoluble in water. SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray or fog. Cool containing vessels with water jet in order to prevent pressure build-up, autoignition or explosion.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill: Absorb with an inert material and put the spilled material in an appropriate waste disposal.

Large Spill:

Toxic flammable liquid, insoluble or very slightly soluble in water. Poisonous liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal.

Section 7: Handling and Storage

Precautions:
Keep locked up.. Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents.

Storage:
Store in a segregated and approved area. Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame).

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protection:
Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid. (Oily liquid.)

Odor: Not available.

Taste: Not available.

Molecular Weight: Not available.

Color: Yellow. Clear (Light.)

pH (1% soln/water): Not applicable.

Boiling Point: 149°C (300.2°F) - 325 C

Melting Point: Not available.

Critical Temperature: Not available.

Specific Gravity: 0.775 - .840(Water = 1)

Vapor Pressure: 0.1 kPa (@ 20°C)

Vapor Density: 4.5 (Air = 1)

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: Not available.

Solubility:
Insoluble in cold water, hot water. Miscible with other petroleum solvents

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Heat, ignition sources (sparks, flames), incompatible materials

Incompatibility with various substances: Reactive with oxidizing agents.

Corrosivity: Not considered to be corrosive for metals and glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Eye contact.

Toxicity to Animals: Acute oral toxicity (LD50): 2835 mg/kg [Rabbit].

Chronic Effects on Humans:
MUTAGENIC EFFECTS: Mutagenic for bacteria and/or yeast. Causes damage to the following organs: the nervous system. May cause damage to the following organs: blood, kidneys, liver, central nervous system (CNS).

Other Toxic Effects on Humans:
Hazardous in case of skin contact (irritant), of ingestion, of inhalation (lung irritant). Slightly hazardous in case of skin contact (permeator).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: May affect genetic material (mutagenic)

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: Causes moderate to severe skin irritation. It can cause defatting dermatitis. Eyes: May cause eye irritation. Inhalation: May cause respiratory tract and mucous membrane irritation and a burning sensation in the chest. Because of its relatively low volatility, overexposure by inhalation is uncommon, but it can occur in poorly ventilated areas or by inhalation of mists or aerosols. Symptoms of inhalation overexposure include central nevous system (CNS) depression (transient euphora, headache, irritability, excitement, ringing in the ears, weakness, incoordination, confusion, disorientation, drowsiness, tremor, somnolence, hallucinations, seizures, coma, death). May affect the heart (cardiac arrythmias), liver, kidneys, and respiration(asphyxia, apnea, acute pulmonary edema, dyspnea, fibrosis, or cyanosis) Ingestion: Causes gastrointestinal tract irritation with burning sensation in mouth, esophagus, and stomach, a b d o m i n a l p a i n , n a u s e a , v o m i t i n g , h y p e r m o t i l i t y , d i a r r h e a , h e a d a c h e , m a l a i s e . M a y a f f e c t respiration/ trachea/bronchi through accidental pulmonary aspiration which can cause hypoxia, chemical pneumonitis, and noncardiogenic pulmonary edema, pulmonary hemmorrhage, coughing, breathing difficulty, acute or chronic pulmonary edema, emphysema, respiratory stimulation. It may also affect the heart (dysrrhythmias, myocardial depression, tachycardia), liver, endocrine system (pancreas - hypoglycemia), behavior/central nervous system (symptoms similar to that of inhalation). Chronic Potential Health Effects: Inhalation: Repeated or prolonged inhalation may cause respiratory tract irritation and affect behavior/central nervous system with symptoms similar to that of acute inhalation. It may also affect the blood (changes in white blood cell count, changes in serum compositon, pigmented or nucleated red blood cells, leukopenia, normocytic anemia) , cardiovascular

system, respiratory system (trachea, bronchi), and may cause kidney damage. Ingestion: Repeated or prolonged ingestion may affect the liver, endocrine system (adrenal gland, pancreas, spleen), and metabolism (weight loss), and blood. Skin: Repeated or prolonged skin contact may cause defatting dermatitis, erythema, and eczema-like skin lesions, drying and cracking of the skin, and possible burns.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: Not available.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: CLASS 3: Flammable liquid.

Identification: : Kerosene UNNA: 1223 PG: III

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:
Connecticut hazardous material survey.: Kerosene Rhode Island RTK hazardous substances: Kerosene Pennsylvania RTK: Kerosene Massachusetts RTK: Kerosene Massachusetts spill list: Kerosene New Jersey: Kerosene TSCA 8(b) inventory: Kerosene

Other Regulations:
OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200). EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada):
CLASS B-3: Combustible liquid with a flash point between 37.8°C (100°F) and 93.3°C (200°F). CLASS D-2B: Material causing other toxic effects (TOXIC).

DSCL (EEC):
R10- Flammable. R65- Harmful: may cause lung damage if swallowed. S23- Do not breathe gas/fumes/vapour/spray S24- Avoid contact with skin. S62- If swallowed, do not induce vomiting: seek medical advice immediately and show this container or label.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 2

Reactivity: 0

Personal Protection: h

National Fire Protection Association (U.S.A.):

Health: 0

Flammability: 2

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Splash goggles.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/09/2005 05:54 PM

Last Updated: 05/21/2013 12:00 PM

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Safety Data Sheet

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND COMPANY/UNDERTAKING

Material Name	:	**Diesel (ULSD/Gasoil)**
Recommended Use / Restrictions of Use	:	Fuel for on-road diesel-powered engines. Fuel for use in off-road diesel engines, boilers, gas turbines and other combustion equipment.
Supplier	:	**Shell Eastern Trading (PTE) Ltd** 9 North Buona Vista Drive, #07-01, Tower 1, The Metropolis Singapore 138588 Singapore
Telephone	:	+65-6384 8000
Emergency Telephone Number	:	+44 (0) 151 350 4595

2. HAZARDS IDENTIFICATION

GHS Classification	:	Flammable liquids, Category 3 Aspiration hazard, Category 1 Acute toxicity, Category 4, Inhalation Skin corrosion/irritation, Category 2 Carcinogenicity, Category 2 Specific target organ toxicity - repeated exposure, Category 2, Blood., Thymus., Liver Hazardous to the aquatic environment - Long-term Hazard, Category 2 Acute hazards to the aquatic environment, Category 2
GHS Label Elements Symbol(s)	:	
Signal Words	:	Danger
Hazard Statement	:	PHYSICAL HAZARDS: H226: Flammable liquid and vapour. HEALTH HAZARDS:

H304: May be fatal if swallowed and enters airways.
H315: Causes skin irritation.
H332: Harmful if inhaled.
H351: Suspected of causing cancer.
H373: May cause damage to organs or organ systems through prolonged or repeated exposure.

ENVIRONMENTAL HAZARDS:
H411: Toxic to aquatic life with long lasting effects.
H401: Toxic to aquatic life.

GHS Precautionary Statements

Prevention : P210: Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
P261: Avoid breathing dust/fume/gas/mist/vapours/spray.
P280: Wear protective gloves/protective clothing/eye protection/face protection.

Response : P301+P310: IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician.
P331: Do NOT induce vomiting.

Disposal: : P501: Dispose of contents and container to appropriate waste site or reclaimer in accordance with local and national regulations.

Other Hazards which do not result in classification : Vapour in the headspace of tanks and containers may ignite and explode at temperatures exceeding auto-ignition temperature, where vapour concentrations are within the flammability range.
May ignite on surfaces at temperatures above auto-ignition temperature.
This material is a static accumulator. Even with proper grounding and bonding, this material can still accumulate an electrostatic charge. If sufficient charge is allowed to accumulate, electrostatic discharge and ignition of flammable air-vapour mixtures can occur.

Additional Information : This product is intended for use in closed systems only.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Mixture Description : Complex mixture of hydrocarbons consisting of paraffins, cycloparaffins, aromatic and olefinic hydrocarbons with carbon

numbers predominantly in the C9 to C25 range. May also contain several additives at <0.1% v/v each. May contain cetane improver (Ethyl Hexyl Nitrate) at <0.2% v/v.

May contain catalytically cracked oils in which polycyclic aromatic compounds, mainly 3-ring but some 4- to 6-ring species are present.

Classification of components according to GHS

Chemical Identity	Synonyms	CAS	Hazard Class (category)	Hazard Statement	Conc.
Fuels, diesel	Fuels, diesel	68334-30-5	Flam. Liq., 3; Asp. Tox., 1; Acute Tox., 4; Skin Corr., 2; Carc., 2; STOT RE, 2; Aquatic Chronic, 2; Aquatic Acute, 2;	H226; H304; H332; H315; H351; H373; H411; H401;	60.00 - 100.00 %
Distillates (Fischer-Tropsch) C8-26 - Branched and Linear	Distillates (Fischer-Tropsch) C8-26 - Branched and Linear	848301-67-7	Asp. Tox., 1; Flam. Liq., 4;	H304; H227;	0.00 - 30.00 %
Kerosine (Fischer Tropsch), Full range, C8-C16 branched and linear alkanes	Kerosine (Fischer Tropsch), Full range, C8-C16 branched and linear alkanes	848301-66-6	Asp. Tox., 1; Flam. Liq., 3;	H304; H226;	0.00 - 10.00 %

Additional Information : Dyes and markers can be used to indicate tax status and prevent fraud. Contains Cumene, CAS# 98-82-8 Contains Naphthalene, CAS # 91-20-3.

Refer to Ch 16 for full text of H phrases.

4. FIRST-AID MEASURES

Inhalation : Remove to fresh air. If rapid recovery does not occur, transport to nearest medical facility for additional treatment.

Skin Contact : Remove contaminated clothing. Immediately flush skin with

		large amounts of water for at least 15 minutes, and follow by washing with soap and water if available. If redness, swelling, pain and/or blisters occur, transport to the nearest medical facility for additional treatment. When using high pressure equipment, injection of product under the skin can occur. If high pressure injuries occur, the casualty should be sent immediately to a hospital. Do not wait for symptoms to develop.
Eye Contact	:	Flush eye with copious quantities of water. If persistent irritation occurs, obtain medical attention.
Ingestion	:	If swallowed, do not induce vomiting: transport to nearest medical facility for additional treatment. If vomiting occurs spontaneously, keep head below hips to prevent aspiration. If any of the following delayed signs and symptoms appear within the next 6 hours, transport to the nearest medical facility: fever greater than 101° F (38.3°C), shortness of breath, chest congestion or continued coughing or wheezing. Give nothing by mouth.
Most Important Symptoms/Effects, Acute & Delayed	:	If material enters lungs, signs and symptoms may include coughing, choking, wheezing, difficulty in breathing, chest congestion, shortness of breath, and/or fever. The onset of respiratory symptoms may be delayed for several hours after exposure. Skin irritation signs and symptoms may include a burning sensation, redness, or swelling.
Immediate medical attention, special treatment	:	Treat symptomatically.

5. FIRE-FIGHTING MEASURES

Clear fire area of all non-emergency personnel.

Specific hazards arising from Chemicals	:	Hazardous combustion products may include: A complex mixture of airborne solid and liquid particulates and gases (smoke). Oxides of sulphur. Unidentified organic and inorganic compounds. Carbon monoxide may be evolved if incomplete combustion occurs. Will float and can be reignited on surface water. Flammable vapours may be present even at temperatures below the flash point. The vapour is heavier than air, spreads along the ground and distant ignition is possible.
Suitable Extinguishing Media	:	Foam, water spray or fog. Dry chemical powder, carbon dioxide, sand or earth may be used for small fires only.
Unsuitable Extinguishing Media	:	Do not use direct water jets on the burning product as they could cause a steam explosion and spread of the fire. Simultaneous use of foam and water on the same surface is to be avoided as water destroys the foam.

Protective Equipment & Precautions for Fire Fighters	:	Proper protective equipment including chemical resistant gloves are to be worn; chemical resistant suit is indicated if large contact with spilled product is expected. Self-Contained Breathing Apparatus must be worn when approaching a fire in a confined space. Select fire fighter's clothing approved to relevant Standards (e.g. Europe: EN469).
Additional Advice	:	Keep adjacent containers cool by spraying with water. If possible remove containers from the danger zone. If the fire cannot be extinguished the only course of action is to evacuate immediately. Contain residual material at affected sites to prevent material from entering drains (sewers), ditches, and waterways.

6. ACCIDENTAL RELEASE MEASURES

Avoid contact with spilled or released material. For guidance on selection of personal protective equipment see Chapter 8 of this Material Safety Data Sheet. See Chapter 13 for information on disposal. Observe the relevant local and international regulations. Evacuate the area of all non-essential personnel. Ventilate contaminated area thoroughly. Take precautionary measures against static discharges.

Personal Precautions, Protective Equipment and Emergency Procedures	:	Do not breathe fumes, vapour. Do not operate electrical equipment. Shut off leaks, if possible without personal risks. Remove all possible sources of ignition in the surrounding area and evacuate all personnel. Attempt to disperse the gas or to direct its flow to a safe location for example by using fog sprays. Take precautionary measures against static discharge. Ensure electrical continuity by bonding and grounding (earthing) all equipment. Monitor area with combustible gas meter.
Environmental Precautions	:	Take measures to minimise the effects on groundwater. Contain residual material at affected sites to prevent material from entering drains (sewers), ditches, and waterways. Prevent from spreading or entering into drains, ditches or rivers by using sand, earth, or other appropriate barriers.
Methods and Material for Containment and Cleaning Up	:	Take precautionary measures against static discharges. For small liquid spills (< 1 drum), transfer by mechanical means to a labelled, sealable container for product recovery or safe disposal. Allow residues to evaporate or soak up with an appropriate absorbent material and dispose of safely. Remove contaminated soil and dispose of safely. For large liquid spills (> 1 drum), transfer by mechanical means such as vacuum truck to a salvage tank for recovery or safe disposal. Do not flush away residues with water. Retain as contaminated waste. Allow residues to evaporate or soak up with an appropriate

absorbent material and dispose of safely. Remove contaminated soil and dispose of safely. Shovel into a suitable clearly marked container for disposal or reclamation in accordance with local regulations.

Additional Advice : Notify authorities if any exposure to the general public or the environment occurs or is likely to occur. Local authorities should be advised if significant spillages cannot be contained. Maritime spillages should be dealt with using a Shipboard Oil Pollution Emergency Plan (SOPEP), as required by MARPOL Annex 1 Regulation 26.

7. HANDLING AND STORAGE

General Precautions : Avoid breathing vapours or contact with material. Only use in well ventilated areas. Wash thoroughly after handling. For guidance on selection of personal protective equipment see Chapter 8 of this Material Safety Data Sheet. Use the information in this data sheet as input to a risk assessment of local circumstances to help determine appropriate controls for safe handling, storage and disposal of this material. Air-dry contaminated clothing in a well-ventilated area before laundering. Prevent spillages. Use local exhaust ventilation if there is risk of inhalation of vapours, mists or aerosols. Never siphon by mouth. Contaminated leather articles including shoes cannot be decontaminated and should be destroyed to prevent reuse.
Maintenance and Fuelling Activities - Avoid inhalation of vapours and contact with skin.

Precautions for Safe Handling : Avoid inhaling vapour and/or mists. Avoid prolonged or repeated contact with skin. When using do not eat or drink. Extinguish any naked flames. Do not smoke. Remove ignition sources. Avoid sparks. Earth all equipment. Properly dispose of any contaminated rags or cleaning materials in order to prevent fires. Use local exhaust ventilation if there is risk of inhalation of vapours, mists or aerosols. The vapour is heavier than air, spreads along the ground and distant ignition is possible.

Conditions for Safe Storage : Drum and small container storage: Drums should be stacked to a maximum of 3 high. Use properly labelled and closeable containers. Tank storage: Tanks must be specifically designed for use with this product. Bulk storage tanks should be diked (bunded). Locate tanks away from heat and other sources of ignition. Must be stored in a diked (bunded) well-ventilated area, away from sunlight, ignition sources and other sources of heat. Vapours from tanks should not be released to

		atmosphere. Breathing losses during storage should be controlled by a suitable vapour treatment system. The vapour is heavier than air. Beware of accumulation in pits and confined spaces. Keep container tightly closed and in a cool, well-ventilated place. Keep in a cool place. Electrostatic charges will be generated during pumping. Electrostatic discharge may cause fire. Ensure electrical continuity by bonding and grounding (earthing) all equipment to reduce the risk. The vapours in the head space of the storage vessel may lie in the flammable/explosive range and hence may be flammable. Refer to section 15 for any additional specific legislation covering the packaging and storage of this product. Keep in a bunded area with a sealed (low permeability) floor, to provide containment against spillage. Prevent ingress of water.
Product Transfer	:	Avoid splash filling. Wait 2 minutes after tank filling (for tanks such as those on road tanker vehicles) before opening hatches or manholes. Wait 30 minutes after tank filling (for large storage tanks) before opening hatches or manholes. Keep containers closed when not in use. Contamination resulting from product transfer may give rise to light hydrocarbon vapour in the headspace of tanks that have previously contained gasoline. This vapour may explode if there is a source of ignition. Partly filled containers present a greater hazard than those that are full, therefore handling, transfer and sampling activities need special care. Even with proper grounding and bonding, this material can still accumulate an electrostatic charge. If sufficient charge is allowed to accumulate, electrostatic discharge and ignition of flammable air-vapour mixtures can occur. Be aware of handling operations that may give rise to additional hazards that result from the accumulation of static charges. These include but are not limited to pumping (especially turbulent flow), mixing, filtering, splash filling, cleaning and filling of tanks and containers, sampling, switch loading, gauging, vacuum truck operations, and mechanical movements. These activities may lead to static discharge e.g. spark formation. Restrict line velocity during pumping in order to avoid generation of electrostatic discharge (<= 1 m/s until fill pipe submerged to twice its diameter, then <= 7 m/s). Avoid splash filling. Do NOT use compressed air for filling, discharging, or handling operations.
Recommended Materials	:	For containers, or container linings use mild steel, stainless steel. Aluminium may also be used for applications where it does not present an unnecessary fire hazard. Examples of suitable materials are: high density polyethylene (HDPE) and Viton (FKM), which have been specifically tested for compatibility with this product. For container linings, use

		amine-adduct cured epoxy paint. For seals and gaskets use: graphite, PTFE, Viton A, Viton B.
Unsuitable Materials	:	Some synthetic materials may be unsuitable for containers or container linings depending on the material specification and intended use. Examples of materials to avoid are: natural rubber (NR), nitrile rubber (NBR), ethylene propylene rubber (EPDM), polymethyl methacrylate (PMMA), polystyrene, polyvinyl chloride (PVC), polyisobutylene. However, some may be suitable for glove materials.
Container Advice	:	Containers, even those that have been emptied, can contain explosive vapours. Do not cut, drill, grind, weld or perform similar operations on or near containers.
Other Advice	:	Ensure that all local regulations regarding handling and storage facilities are followed. See additional references that provide safe handling practices for liquids that are determined to be static accumulators: American Petroleum Institute 2003 (Protection Against Ignitions Arising out of Static, Lightning and Stray Currents) or National Fire Protection Agency 77 (Recommended Practices on Static Electricity). CENELEC CLC/TR 50404 (Electrostatics – Code of practice for the avoidance of hazards due to static electricity).

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

If the American Conference of Governmental Industrial Hygienists (ACGIH) value is provided on this document, it is provided for information only.

Occupational Exposure Limits

Material	Source	Type	ppm	mg/m3	Notation
Naphthalene	ACGIH	TWA	10 ppm		
	ACGIH	STEL	15 ppm		
	ACGIH	SKIN_DES			Can be absorbed through the skin.
	SG OEL	TWA	10 ppm	52 mg/m3	
	SG OEL	STEL	15 ppm	79 mg/m3	

Safety Data Sheet

Fuels, diesel	ACGIH	SKIN_DES(Inhalable fraction and vapor.)			Can be absorbed through the skin.as total hydrocarbons
	ACGIH	TWA(Inhalable fraction and vapor.)		100 mg/m3	as total hydrocarbons
Cumene	ACGIH	TWA	50 ppm		
	SG OEL	TWA	50 ppm	246 mg/m3	

Additional Information : Skin notation means that significant exposure can also occur by absorption of liquid through the skin and of vapour through the eyes or mucous membranes.

Biological Exposure Index (BEI)

Material	Determinant	Sampling Time	BEI	Reference
Naphthalene	1-Naphthol, with hydrolysis + 2-Naphthol, with hydrolysis	Sampling time: End of shift.		ACGIH BEL (02 2013)

Appropriate Engineering Controls : The level of protection and types of controls necessary will vary depending upon potential exposure conditions. Select controls based on a risk assessment of local circumstances. Appropriate measures include: Use sealed systems as far as possible. Adequate explosion-proof ventilation to control airborne concentrations below the exposure guidelines/limits. Local exhaust ventilation is recommended. Eye washes and showers for emergency use. Always observe good personal hygiene measures, such as washing hands after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants. Discard contaminated clothing and footwear that cannot be cleaned. Practice good housekeeping. Define procedures for safe handling and maintenance of controls.

Educate and train workers in the hazards and control measures relevant to normal activities associated with this product. Ensure appropriate selection, testing and maintenance of equipment used to control exposure, e.g. personal protective equipment, local exhaust ventilation. Firewater monitors and deluge systems are recommended. Drain down system prior to equipment break-in or maintenance. Retain drain downs in sealed storage pending disposal or for subsequent recycle.

Individual Protection Measures : Personal protective equipment (PPE) should meet recommended national standards. Check with PPE suppliers.

Respiratory Protection : If engineering controls do not maintain airborne concentrations to a level which is adequate to protect worker health, select respiratory protection equipment suitable for the specific conditions of use and meeting relevant legislation. Check with respiratory protective equipment suppliers. Where air-filtering respirators are suitable, select an appropriate combination of mask and filter. Where air-filtering respirators are unsuitable (e.g. airborne concentrations are high, risk of oxygen deficiency, confined space) use appropriate positive pressure breathing apparatus. All respiratory protection equipment and use must be in accordance with local regulations. Select a filter suitable for combined particulate/organic gases and vapours [boiling point >65°C(149 °F)].

Hand Protection : Personal hygiene is a key element of effective hand care. Gloves must only be worn on clean hands. After using gloves, hands should be washed and dried thoroughly. Application of a non-perfumed moisturizer is recommended. Suitability and durability of a glove is dependent on usage, e.g. frequency and duration of contact, chemical resistance of glove material, dexterity. Always seek advice from glove suppliers. Contaminated gloves should be replaced. For continuous contact we recommend gloves with breakthrough time of more than 240 minutes with preference for > 480 minutes where suitable gloves can be identified. For short-term/splash protection we recommend the same, but recognise that suitable gloves offering this level of protection may not be available and in this case a lower breakthrough time may be acceptable so long as appropriate maintenance and replacement regimes are followed. Glove thickness is not a good predictor of glove resistance to a chemical as it is dependent on the exact composition of the glove material. Select gloves tested to a relevant standard (e.g. Europe EN374, US F739). When prolonged or frequent repeated contact occurs, Nitrile gloves may be suitable. (Breakthrough

		time of > 240 minutes.) For incidental contact/splash protection Neoprene, PVC gloves may be suitable.
Eye Protection	:	Chemical splash goggles (chemical monogoggles). If a local risk assessment deems it so, then chemical splash goggles may not be required and safety glasses may provide adequate eye protection.
Protective Clothing	:	Chemical resistant gloves/gauntlets, boots, and apron (where risk of splashing).
Thermal Hazards	:	Not applicable.
Monitoring Methods	:	Monitoring of the concentration of substances in the breathing zone of workers or in the general workplace may be required to confirm compliance with an OEL and adequacy of exposure controls. For some substances biological monitoring may also be appropriate. Validated exposure measurement methods should be applied by a competent person and samples analysed by an accredited laboratory. Examples of sources of recommended exposure measurement methods are given below or contact the supplier. Further national methods may be available. National Institute of Occupational Safety and Health (NIOSH), USA: Manual of Analytical Methods http://www.cdc.gov/niosh/ Occupational Safety and Health Administration (OSHA), USA: Sampling and Analytical Methods http://www.osha.gov/
Environmental Exposure Controls	:	Local guidelines on emission limits for volatile substances must be observed for the discharge of exhaust air containing vapour. Information on accidental release measures are to be found in section 6. Take appropriate measures to fulfil the requirements of relevant environmental protection legislation. Avoid contamination of the environment by following advice given in Chapter 6. If necessary, prevent undissolved material from being discharged to waste water. Waste water should be treated in a municipal or industrial waste water treatment plant before discharge to surface water.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	:	Colourless to yellowish. Liquid.
Odour	:	May contain a reodorant
Odour threshold	:	Data not available
pH	:	Not applicable
Initial Boiling Point and Boiling Range	:	170 - 390 °C / 338 - 734 °F
Pour point	:	<= 6 °C / 43 °F
Flash point	:	> 55 °C / 131 °F
Upper / lower Flammability or	:	1 - 6 %(V)

Explosion limits		
Auto-ignition temperature	:	> 220 °C / 428 °F
Vapour pressure	:	1 hPa at 20 °C / 68 °F
Relative Density	:	Data not available
Density	:	0.8 - 0.89 g/cm3 at 15 °C / 59 °F
Water solubility	:	Data not available
Solubility in other solvents	:	Data not available
n-octanol/water partition coefficient (log Pow)	:	3 - 6
Dynamic viscosity	:	Data not available
Kinematic viscosity	:	1.5 - 6 mm2/s at 40 °C / 104 °F
Vapour density (air=1)	:	Data not available
Electrical conductivity	:	Low conductivity: < 100 pS/m, The conductivity of this material makes it a static accumulator., A liquid is typically considered nonconductive if its conductivity is below 100 pS/m and is considered semi-conductive if its conductivity is below 10 000 pS/m., Whether a liquid is nonconductive or semi-conductive, the precautions are the same., A number of factors, for example liquid temperature, presence of contaminants, and anti-static additives can greatly influence the conductivity of a liquid.
Evaporation rate (nBuAc=1)	:	Data not available
Decomposition Temperature	:	Data not available
Flammability	:	Not applicable.

10. STABILITY AND REACTIVITY

Chemical stability	:	Stable under normal use conditions.
Possibility of Hazardous Reactions	:	No hazardous reaction is expected when handled and stored according to provisions.
Conditions to Avoid	:	Avoid heat, sparks, open flames and other ignition sources.
Incompatible Materials	:	Strong oxidising agents.
Hazardous Decomposition Products	:	Hazardous decomposition products are not expected to form during normal storage. Thermal decomposition is highly dependent on conditions. A complex mixture of airborne solids, liquids and gases, including carbon monoxide, carbon dioxide and other organic compounds will be evolved when this material undergoes combustion or thermal or oxidative degradation.
Sensitivity to Static Discharge	:	Yes, in certain circumstances product can ignite due to static electricity.

11. TOXICOLOGICAL INFORMATION

Information on Toxicological effects

Basis for Assessment	:	Information given is based on product data, a knowledge of the components and the toxicology of similar products. Unless indicated otherwise, the data presented is representative of the product as a whole, rather than for individual component(s).
Likely Routes of Exposure	:	Exposure may occur via inhalation, ingestion, skin absorption, skin or eye contact, and accidental ingestion.
Acute Oral Toxicity	:	Low toxicity: LD50 > 5000 mg/kg , Rat
Acute Dermal Toxicity	:	Low toxicity: LD50 >2000 mg/kg , Rabbit
Acute Inhalation Toxicity	:	Harmful if inhaled. LC50 > 1.0 - <= 5.0 mg/l , 4 h, Rat High concentrations may cause central nervous system depression resulting in headaches, dizziness and nausea; continued inhalation may result in unconsciousness and/or death.
Skin corrosion/irritation	:	Irritating to skin.
Serious eye damage/irritation	:	Expected to be slightly irritating.
Respiratory Irritation	:	Inhalation of vapours or mists may cause irritation to the respiratory system.
Respiratory or skin sensitisation	:	Not expected to be a sensitiser.
Aspiration Hazard	:	Aspiration into the lungs when swallowed or vomited may cause chemical pneumonitis which can be fatal.
Germ cell mutagenicity	:	Positive in in-vitro, but negative in in-vivo mutagenicity assays.
Carcinogenicity	:	Limited evidence of carcinogenic effect. Repeated skin contact has resulted in irritation and skin cancer in animals.

Material	:	**Carcinogenicity Classification**
Naphthalene	:	ACGIH Group A4: Not classifiable as a human carcinogen.
Naphthalene	:	NTP: Reasonably Anticipated to be a Human Carcinogen.
Naphthalene	:	IARC 2B: Possibly carcinogenic to humans.
Naphthalene	:	GHS / CLP: Carcinogenicity Category 2

Fuels, diesel	:	ACGIH Group A3: Confirmed animal carcinogen with unknown relevance to humans.
Fuels, diesel	:	GHS / CLP: Carcinogenicity Category 2
Distillates (Fischer-Tropsch) C8-26 - Branched and Linear	:	GHS / CLP: No carcinogenicity classification
Kerosine (Fischer Tropsch), Full range, C8-C16 branched and linear alkanes	:	GHS / CLP: No carcinogenicity classification
Cumene	:	IARC 2B: Possibly carcinogenic to humans.
Cumene	:	GHS / CLP: No carcinogenicity classification

Reproductive and Developmental Toxicity : Not expected to impair fertility. Not expected to be a developmental toxicant.

Specific target organ toxicity - single exposure : Not classified.

Specific target organ toxicity - repeated exposure : May cause damage to organs or organ systems through prolonged or repeated exposure. Blood. Thymus. Liver.

Additional Information : Classifications by other authorities under varying regulatory frameworks may exist.

12. ECOLOGICAL INFORMATION

Basis for Assessment : Information given is based on a knowledge of the components and the ecotoxicology of similar products. Fuels are typically made from blending several refinery streams. Ecotoxicological studies have been carried out on a variety of hydrocarbon blends and streams but not those containing additives. Unless indicated otherwise, the data presented is representative of the product as a whole, rather than for individual component(s).

Acute Toxicity : Expected to be toxic: LL/EL/IL50 > 1 <= 10 mg/l (to aquatic organisms) LL/EL50 expressed as the nominal amount of product required to prepare aqueous test extract.

Fish : Expected to be toxic: LL/EL/IL50 > 1 <= 10 mg/l

Aquatic crustacea : Expected to be toxic: LL/EL/IL50 > 1 <= 10 mg/l

Algae/aquatic plants : Expected to be toxic: LL/EL/IL50 > 1 <= 10 mg/l

Microorganisms : Expected to be practically non toxic: LL/EL/IL50 > 100 mg/l

Chronic Toxicity

Fish : NOEC/NOEL expected to be > 0.01 - <= 0.1 mg/l (based on

		modeled data)
Aquatic crustacea	:	NOEC/NOEL expected to be > 0.1 - <= 1.0 mg/l (based on modeled data)
Mobility	:	Partly evaporates from water or soil surfaces, but a significant proportion will remain after one day. If product enters soil, one or more constituents will be mobile and may contaminate groundwater. Large volumes may penetrate soil and could contaminate groundwater. Floats on water.
Persistence/degradability	:	Major constituents are inherently biodegradable. The volatile constituents will oxidize rapidly by photochemical reactions in air.
Bioaccumulative Potential	:	Contains constituents with the potential to bioaccumulate. Log Kow > =4
Other Adverse Effects	:	Films formed on water may affect oxygen transfer and damage organisms.

13. DISPOSAL CONSIDERATIONS

Material Disposal	:	Recover or recycle if possible. It is the responsibility of the waste generator to determine the toxicity and physical properties of the material generated to determine the proper waste classification and disposal methods in compliance with applicable regulations. Do not dispose into the environment, in drains or in water courses. Do not dispose of tank water bottoms by allowing them to drain into the ground. This will result in soil and groundwater contamination. Waste arising from a spillage or tank cleaning should be disposed of in accordance with prevailing regulations, preferably to a recognised collector or contractor. The competence of the collector or contractor should be established beforehand.
Container Disposal	:	Send to drum recoverer or metal reclaimer. Drain container thoroughly. After draining, vent in a safe place away from sparks and fire. Residues may cause an explosion hazard if heated above the flash point. Do not puncture, cut or weld uncleaned drums. Do not pollute the soil, water or environment with the waste container. Comply with any local recovery or waste disposal regulations.
Local Legislation	:	Disposal should be in accordance with applicable regional, national, and local laws and regulations. Local regulations may be more stringent than regional or national requirements and must be in compliance.

14. TRANSPORT INFORMATION

Land (as per ADR classification): Regulated

Class	:	3
Packing group	:	III
Hazard indentification no.	:	30
UN number	:	1202
Danger label (primary risk)	:	3
Proper shipping name	:	DIESEL FUEL
Environmentally Hazardous	:	Yes

IMDG

Identification number	UN 1202
Proper shipping name	DIESEL FUEL
Class / Division	3
Packing group	III
Environmental hazards:	Yes

IATA (Country variations may apply)

UN number	:	1202
Proper shipping name	:	Diesel fuel
Class / Division	:	3
Packing group	:	III

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code

Pollution Category	**:**	Not applicable.
Ship Type	**:**	Not applicable.
Product Name	**:**	Not applicable.
Special Precaution	**:**	Not applicable.
Additional Information	**:**	MARPOL Annex 1 rules apply for bulk shipments by sea.

15. REGULATORY INFORMATION

The regulatory information is not intended to be comprehensive. Other regulations may apply to this material.

Local Regulations

Workplace Safety and Health Act & Workplace Safety and Health (General Provision) Regulations	:	This product is subject to the requirement in the Act/ Regulations.
Environmental Protection and Management Act and Environmental Protection and Management	:	This product is subject to the requirement in the Act/ Regulations.

(Hazardous Substances) Regulations		
Maritime and Port Authority of Singapore (Dangerous Goods, Petroleum and Explosives) Regulations	:	This product is subject to the requirement in the Act/ Regulations.
Fire Safety Act and Fire Safety (Petroleum & Flammable Materials) Regulations	:	This product is subject to the requirement in the Act/ Regulations.
Classification triggering components	:	Contains fuels, diesel.
Other Information	:	IARC has classified diesel exhaust emissions as a Class 1 carcinogen - carcinogenic to humans. Steps should be taken to prevent personal exposure to diesel exhaust emissions.

16. OTHER INFORMATION

Hazard Statement

H226	Flammable liquid and vapour.
H227	Combustible liquid.
H304	May be fatal if swallowed and enters airways.
H315	Causes skin irritation.
H332	Harmful if inhaled.
H351	Suspected of causing cancer.
H373	May cause damage to organs or organ systems through prolonged or repeated exposure.
H401	Toxic to aquatic life.
H411	Toxic to aquatic life with long lasting effects.

Additional Information	:	This document contains important information to ensure the safe storage, handling and use of this product. The information in this document should be brought to the attention of the person in your organisation responsible for advising on safety matters.
SDS Version Number	:	1.1
SDS Effective Date	:	10.03.2014
SDS Revisions	:	A vertical bar (|) in the left margin indicates an amendment from the previous version.
Uses and Restrictions	:	This product must not be used in applications other than those recommended in Section 1, without first seeking the advice of the supplier. This product is not to be used as a solvent or cleaning agent;

Safety Data Sheet

for lighting or brightening fires; as a skin cleanser.

SDS Distribution : The information in this document should be made available to all who may handle the product.

Key/Legend to Abbrevations used in this SDS : The standard abbreviations and acronyms used in this document can be looked up in reference literature (e.g. scientific dictionaries) and/or websites.

Flam. Liq.	Flammable liquids
Asp. Tox.	Aspiration hazard
Acute Tox.	Acute toxicity
Skin Corr.	Skin corrosion/irritation
Carc.	Carcinogenicity
STOT RE	Specific target organ toxicity - repeated exposure

Key Literature References : The quoted data are from, but not limited to, one or more sources of information (e.g. toxicological data from Shell Health Services, material suppliers' data, CONCAWE, EU IUCLID date base, EC 1272 regulation, etc).

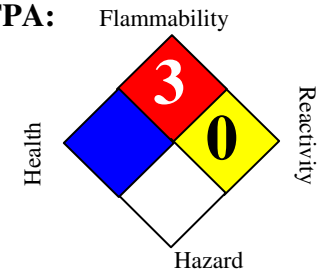
Disclaimer : This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not therefore be construed as guaranteeing any specific property of the product.

ANNEXURE-C

MSDS- NAPHTHA

Material Safety Data Sheet
Naphtha

NFPA:



HMIS III:

HEALTH	1
FLAMMABILITY	3
PHYSICAL	0

0 = Insignificant, 1 = Slight, 2 = Moderate,

SECTION

Product name : Naphtha

Synonyms : Light Naphtha, Japan Open Spec Bonded Naphtha, SNG Naphtha, Light Cat Naphtha, Sweet Virgin Naphtha (SVN), Debutanized Naphtha, Atmospheric Naphtha (DAN), HCU Light Naphtha, Light CR Gasoline, Full Range Cracked Naphtha, Full Range Hydrocracked Naphtha, Full Range Reformed Naphtha, Light Chemical Treated Naphtha, Light Cracked Naphtha, Light Hydrocracked Naphtha, Light Hydrotreated Naphtha, Aviation Alkylate Naphtha, 888100004450

MSDS Number : 888100004450 **Version** : 2.12

Product Use Description : Fuel Component, Refinery Intermediate Stream

Company : For: Tesoro Refining & Marketing Co.
19100 Ridgewood Parkway, San Antonio, TX 78259

Tesoro Call Center : (877) 783-7676 **Chemtrec**

SECTION HAZARDS IDENTIFICATION

Emergency Overview

Regulatory status tional Safety and Health Administration (OSHA) Hazard Communication Standard (29 CFR 1910.1200).

Signal Word :

Hazard Summary : tory system. Affects central nervous system. Harmful or fatal if swallowed. Aspiration Hazard.

Potential Health Effects

Eyes : ation and discomfort.

Skin : itation leading to dermatitis may occur upon prolonged or repeated contact. Can be absorbed through skin.

Ingestion : particularly from vomiting after ingestion. Aspiration may result in chemical pneumonia, severe lung damage, respiratory failure and even death.

Inhalation : nose, throat, and lungs, and can cause signs and symptoms of central nervous system depression, depending on the concentration and duration of exposure. Inhalation of high concentrations may cause central nervous system depression such as dizziness,

PRODUCT AND COMPANY IDENTIFICATION

drowsiness, headache, and similar narcotic symptoms, but no long-term effects.

Chronic Exposure : gans, such as to the liver, kidneys, blood, nervous system, and skin. Contains benzene, which can cause blood disease, including anemia and leukemia.

Target Organs :

SECTION COMPOSITION/INFORMATION ON INGREDIENTS

Component	CAS-No.	Weight %
Naphtha; Low boiling point naphtha	8030-30-6	100%
N-hexane	110-54-3	25 - 35%
Xylene	1330-20-7	25 - 35%
Toluene	108-88-3	15 - 20%
Cyclohexane	110-82-7	15 - 20%
Pentane	109-66-0	15 - 20%
Heptane [and isomers]	142-82-5	12.5 - 15%
Ethylbenzene	100-41-4	5 - 7%
Benzene	71-43-2	3 - 5%
1,2,4-Trimethylbenzene	95-63-6	2 - 3%
Sulfur	7704-34-9	0 - 1.5%

SECTION FIRST AID MEASURES

General advice : Remove from exposure, lie down. In the case of accident or if you feel unwell, seek medical advice immediately (show the label where possible). When symptoms persist or in all cases of doubt, seek medical advice. Never give anything by mouth to an unconscious person. Take off all contaminated clothing immediately and thoroughly wash material from skin.

Inhalation : If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Seek medical attention immediately.

Skin contact : In case of contact, immediately flush skin with plenty of water. Take off contaminated clothing and shoes immediately. Wash contaminated clothing before re-use. Contaminated leather, particularly footwear, must be discarded. Note that contaminated clothing may be a fire hazard. Seek medical advice if symptoms persist or develop.

Eye contact : Remove contact lenses. In the case of contact with eyes, rinse immediately with plenty of water and seek medical advice.

Ingestion : If swallowed Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Seek medical attention immediately.

Skin Central nervous system Liver Kidneys Blood

Notes to physician	:	Dizziness, Discomfort, Headache, Nausea, Kidney disorders, Liver disorders.

SECTION -FIGHTING MEASURES

Form	:	Liquid
Flash point -typical	:	-21.7 °C (-7.1 °F)
Auto Ignition temperature	:	225 °C (437 °F)
Lower explosive limit	:	1.2 %(V)
Upper explosive limit	:	6.9 % (V)
Suitable extinguishing media	:	Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide. Do not use a solid water stream as it may scatter and spread fire.
Specific hazards during fire fighting	:	SMALL FIRES: Any extinguisher suitable for Class B fires, dry chemical, CO2, water spray, fire fighting foam, or Halon. LARGE FIRES: Water spray, fog or fire fighting foam. Water may be ineffective for fighting the fire, but may be used to cool fire-exposed containers.
Special protective equipment for fire-fighters	:	Fire fighters should wear positive pressure self-contained breathing apparatus (SCBA) and full turnout gear. Firefighters' protective clothing will provide limited protection.
Further information	:	Isolate area around container involved in fire. Cool tanks, shells, and containers exposed to fire and excessive heat with water. For massive fires the use of unmanned hose holders or monitor nozzles may be advantageous to further minimize personnel exposure. Major fires may require withdrawal, allowing the tank to burn. Large storage tank fires typically require specially trained personnel and equipment to extinguish the fire, often including the need for properly applied fire fighting foam. Exposure to decomposition products may be a hazard to health. Use extinguishing measures that are appropriate to local circumstances and the surrounding environment. Use water spray to cool unopened containers. Fire residues and contaminated fire extinguishing water must be disposed of in accordance with local regulations.

SECTION

Personal precautions	:	Evacuate personnel to safe areas. Ventilate the area. Remove all sources of ignition. Response and clean-up crews must be properly trained and must utilize proper protective equipment (see Section 8).
Environmental precautions	:	Should not be released into the environment. Avoid subsoil penetration. If the product contaminates rivers and lakes or drains, inform respective authorities.
Methods for cleaning up	:	Contain and collect spillage with non-combustible absorbent material, (e.g. sand, earth, diatomaceous earth, vermiculite) and place in container for disposal according to local / national regulations.

SECTION

Handling	:	Keep away from fire, sparks and heated surfaces. No smoking near areas where material is stored or handled. The product should only be stored and handled in

7. [illegible] EASURES

areas with intrinsically safe electrical classification.

Advice on protection against fire and explosion : Hydrocarbon liquids including this product can act as a non-conductive flammable liquid (or static accumulators), and may form ignitable vapor-air mixtures in storage tanks or other containers. Precautions to prevent static-initated fire or explosion during transfer, storage or handling, include but are not limited to these examples:

(1) Ground and bond containers during product transfers. Grounding and bonding may not be adequate protection to prevent ignition or explosion of hydrocarbon liquids and vapors that are static accumulators.
(2) Special slow load procedures for "switch loading" must be followed to avoid the static ignition hazard that can exist when higher flash point material (such as fuel oil or diesel) is loaded into tanks previously containing low flash point products (such gasoline or naphtha).
(3) Storage tank level floats must be effectively bonded.

For more information on precautions to prevent static-initated fire or explosion, see NFPA 77, Recommended Practice on Static Electricity (2007), and API Recommended Practice 2003, Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents (2008).

Dust explosion class : Not applicable

Requirements for storage areas and containers : Keep away from flame, sparks, excessive temperatures and open flame. Use approved containers. Keep containers closed and clearly labeled. Empty or partially full product containers or vessels may contain explosive vapors. Do not pressurize, cut, heat, weld or expose containers to sources of ignition. Store in a well-ventilated area. The storage area should comply with NFPA 30 "Flammable and Combustible Liquid Code". The cleaning of tanks previously containing this product should follow API Recommended Practice (RP) 2013 "Cleaning Mobile Tanks In Flammable and Combustible Liquid Service" and API RP 2015 "Cleaning Petroleum Storage Tanks".

Advice on common storage : Keep away from food, drink and animal feed. Incompatible with oxidizing agents. Incompatible with acids.

Other data :

SECTION

Exposure Guidelines

List	Components	CAS-No.	Type:	Value
OSHA	Benzene - 29 CFR 1910.1028	71-43-2	TWA	1 ppm
		71-43-2	STEL	5 ppm
		71-43-2	OSHA_AL	0.5 ppm
OSHA Z1	Naphtha; Low boiling point naphtha	8030-30-6	PEL	100 ppm 400 mg/m3
	Xylene	1330-20-7	PEL	100 ppm 435 mg/m3
	N-hexane	110-54-3	PEL	500 ppm 1,800 mg/m3
	Cyclohexane	110-82-7	PEL	300 ppm 1,050 mg/m3
	Heptane [and isomers]	142-82-5	PEL	500 ppm 2,000 mg/m3
	Ethylbenzene	100-41-4	PEL	100 ppm 435 mg/m3
ACGIH	Naphtha; Low boiling point naphtha	8030-30-6	TWA	400 ppm

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

No Hazardous Ingredients Identified Above Threshold Limits

	Xylene	1330-20-7	TWA	100 ppm
		1330-20-7	STEL	150 ppm
	N-hexane	110-54-3	TWA	50 ppm
	Toluene	108-88-3	TWA	50 ppm
	Cyclohexane	110-82-7	TWA	100 ppm
	Pentane	109-66-0	TWA	600 ppm
	Heptane [and isomers]	142-82-5	TWA	400 ppm
		142-82-5	STEL	500 ppm
	Ethylbenzene	100-41-4	TWA	100 ppm
		100-41-4	STEL	125 ppm
	Benzene	71-43-2	TWA	0.5 ppm
		71-43-2	STEL	2.5 ppm

Engineering measures : Use adequate ventilation to keep gas and vapor concentrations of this product below occupational exposure and flammability limits, particularly in confined spaces. Use only intrinsically safe electrical equipment approved for use in classified areas.

Eye protection : Safety glasses or goggles are recommended where there is a possibility of splashing or spraying. Ensure that eyewash stations and safety showers are close to the workstation location.

Hand protection : Gloves constructed of nitrile or neoprene are recommended. Consult manufacturer specifications for further information.

Skin and body protection : If needed to prevent skin contact, chemical protective clothing such as of DuPont TyChem®, Saranex or equivalent recommended based on degree of exposure. The resistance of specific material may vary from product to product as well as with degree of exposure.

Respiratory protection : A NIOSH/ MSHA-approved air-purifying respirator with organic vapor cartridges or canister may be permissible under certain circumstances where airborne concentrations are or may be expected to exceed exposure limits or for odor or irritation. Protection provided by air-purifying respirators is limited. Refer to OSHA 29 CFR 1910.134, ANSI Z88.2-1992, NIOSH Respirator Decision Logic, and the manufacturer for additional guidance on respiratory protection selection. Use a NIOSH/ MSHA-approved positive-pressure supplied-air respirator if there is a potential for uncontrolled release, exposure levels are not known, in oxygen-deficient atmospheres, or any other circumstance where an air-purifying respirator may not provide adequate protection.

Work / Hygiene practices : Emergency eye wash capability should be available in the near proximity to operations presenting a potential splash exposure. Use good personal hygiene practices. Avoid repeated and/or prolonged skin exposure. Wash hands before eating, drinking, smoking, or using toilet facilities. Do not use as a cleaning solvent on the skin. Do not use solvents or harsh abrasive skin cleaners for washing this product from exposed skin areas. Waterless hand cleaners are effective. Promptly remove contaminated clothing and launder before reuse. Use care when laundering to prevent the formation of flammable vapors which could ignite via washer or dryer. Consider the need to discard contaminated leather shoes and gloves.

SECTION

Form	:	
Appearance	:	
Odor	:	
Flash point -	:	
Auto Ignition temperature	:	
Thermal decomposition	:	on if stored and applied as directed.
Lower explosive limit	:	
Upper explosive limit	:	
pH	:	
Specific gravity	:	
Boiling point	:	
Vapor Pressure	:	at 20 °C (68 °F)
Vapor Density (Air = 1)	:	
Water solubility	:	
Viscosity, kinematic	:	
Percent Volatiles	:	
Work / Hygiene practices		in the near proximity to operations presenting a potential splash exposure. Use good personal hygiene practices. Avoid repeated and/or prolonged skin exposure. Wash hands before eating, drinking, smoking, or using toilet facilities. Do not use as a cleaning solvent on the skin. Do not use solvents or harsh abrasive skin cleaners for washing this product from exposed skin areas. Waterless hand cleaners are effective. Promptly remove contaminated clothing and launder before reuse. Use care when laundering to prevent the formation of flammable vapors which could ignite via washer or dryer. Consider the need to discard contaminated leather shoes and gloves.

SECTION

Conditions to avoid	:	ng, smoking and other ignition sources.
Materials to avoid	:	
Hazardous decomposition products	:	drocarbons (smoke).
Thermal decomposition	:	on if stored and applied as directed.
Hazardous reactions	:	us polymerization does not occur. Note: Stable under recommended storage conditions.

[illegible] PROPERTIES

SECTION

Carcinogenicity

NTP

IARC

Benzene (CAS-No.: 71-43-2)

OSHA

CA Prop 65

the State of California to cause cancer.
Ethylbenzene (CAS-No.: 100-41-4)
Benzene (CAS-No.: 71-43-2)

the State of California to cause birth defects or other reproductive harm.
Toluene (CAS-No.: 108-88-3)
Benzene (CAS-No.: 71-43-2)

Skin irritation : Repeated or prolonged contact with the preparation may cause removal of natural fat from the skin resulting in desiccation of the skin.
The product may be absorbed through the skin.

Eye irritation : The liquid splashed in the eyes may cause irritation and reversible damage.
Strong lachrymation can make it difficult to escape

Further information : This product contains benzene. Human health studies indicate that prolonged and/or repeated overexposure to benzene may cause damage to the blood-forming system (particularly bone marrow), and serious blood disorders such as aplastic anemia and leukemia. Benzene is listed as a human carcinogen by the NTP, IARC, OSHA and ACGIH. Acute toxicity of benzene results primarily from depression of the central nervous system (CNS). Inhalation of concentrations over 50 ppm can produce headache, lassitude, weariness, dizziness, drowsiness, or excitation. Exposure to very high levels can result in unconsciousness and death.
Symptoms of overexposure may be headache, dizziness, tiredness, nausea and vomiting.
Ingestion may cause gastrointestinal disturbances, including irritation, nausea, vomiting and diarrhea, and central nervous (brain) effects similar to alcohol intoxication. In severe cases, tremors, convulsions, loss of consciousness, coma, respiratory arrest and death may occur.

Component:

11. TOXICOLOGICAL INFORMATION known to

N-hexane	110-54-3	Acute oral toxicity: LD50 rat Dose: 25,000 mg/kg Acute dermal toxicity: LD50 rabbit Dose: 2,001 mg/kg Acute inhalation toxicity: LC50 rat Dose: 171.6 mg/l Exposure time: 4 h Skin irritation: Classification: Irritating to skin. Result: Skin irritation Eye irritation: Classification: Irritating to eyes. Result: Mild eye irritation Teratogenicity: N11.00418960
Xylene	1330-20-7	Acute oral toxicity: LD50 rat Dose: 2,840 mg/kg Acute dermal toxicity: LD50 rabbit Dose: ca. 4,500 mg/kg Acute inhalation toxicity: LC50 rat Dose: 6,350 mg/l Exposure time: 4 h Skin irritation: Classification: Irritating to skin. Result: Mild skin irritation Repeated or prolonged exposure may cause skin irritation and dermatitis, due to degreasing properties of the product. Eye irritation: Classification: Irritating to eyes. Result: Mild eye irritation
Toluene	108-88-3	Acute oral toxicity: LD50 rat Dose: 636 mg/kg Acute dermal toxicity: LD50 rabbit Dose: 12,124 mg/kg Acute inhalation toxicity: LC50 rat Dose: 49 mg/l Exposure time: 4 h Skin irritation: Classification: Irritating to skin. Result: Mild skin irritation Prolonged skin contact may defat the skin and produce dermatitis. Eye irritation: Classification: Irritating to eyes. Result: Mild eye irritation
Cyclohexane	110-82-7	Acute dermal toxicity: LD50 rabbit Dose: 2,001 mg/kg Acute inhalation toxicity: LC50 rat Dose: 14 mg/l Exposure time: 4 h Skin irritation: Classification: Irritating to skin. Result: Skin irritation Eye irritation: Classification: Irritating to eyes. Result: Mild eye irritation
Pentane	109-66-0	Acute oral toxicity: LD50 rat Dose: 2,001 mg/kg Acute inhalation toxicity: LC50 rat

		Dose: 364 mg/l Exposure time: 4 h Skin irritation: Repeated or prolonged exposure may cause skin irritation and dermatitis, due to degreasing properties of the product. Eye irritation: Classification: Irritating to eyes. Result: Mild eye irritation
Heptane [and isomers]	142-82-5	Acute oral toxicity: LD50 rat Dose: 15,001 mg/kg Acute inhalation toxicity: LC50 rat Dose: 103 g/m3 Exposure time: 4 h Skin irritation: Classification: Irritating to skin. Result: Skin irritation Repeated or prolonged exposure may cause skin irritation and dermatitis, due to degreasing properties of the product. Eye irritation: Classification: Irritating to eyes. Result: Mild eye irritation
Ethylbenzene	100-41-4	Acute oral toxicity: LD50 rat Dose: 3,500 mg/kg Acute dermal toxicity: LD50 rabbit Dose: 15,500 mg/kg Acute inhalation toxicity: LC50 rat Dose: 18 mg/l Exposure time: 4 h Skin irritation: Classification: Irritating to skin. Result: Mild skin irritation Eye irritation: Classification: Irritating to eyes. Result: Risk of serious damage to eyes.
Benzene	71-43-2	Acute oral toxicity: LD50 rat Dose: 930 mg/kg Acute inhalation toxicity: LC50 rat Dose: 44 mg/l Exposure time: 4 h Skin irritation: Classification: Irritating to skin. Result: Mild skin irritation Repeated or prolonged exposure may cause skin irritation and dermatitis, due to degreasing properties of the product. Eye irritation: Classification: Irritating to eyes. Result: Risk of serious damage to eyes.
1,2,4-Trimethylbenzene	95-63-6	Acute inhalation toxicity: LC50 rat Dose: 18 mg/l Exposure time: 4 h Skin irritation: Classification: Irritating to skin. Result: Skin irritation Eye irritation: Classification: Irritating to eyes. Result: Eye irritation

Sulfur	7704-34-9	Acute oral toxicity: LD50 rat Dose: 5,001 mg/kg Acute dermal toxicity: LD50 rabbit Dose: 2,001 mg/kg Acute inhalation toxicity: LC50 rat Dose: 9.24 mg/l Exposure time: 4 h Eye irritation: Classification: Irritating to eyes. Result: Mild eye irritation

SECTION

Additional ecological information : Keep out of sewers, drainage areas, and waterways. Report spills and releases, as applicable, under Federal and State regulations.

Component:

N-hexane	110-54-3	Toxicity to fish: LC50 Species: Pimephales promelas (fathead minnow) Dose: 2.5 mg/l Exposure time: 96 h Acute and prolonged toxicity for aquatic invertebrates: EC50 Species: Daphnia magna (Water flea) Dose: 2.1 mg/l Exposure time: 48 h
Toluene	108-88-3	Toxicity to fish: LC50 Species: Carassius auratus (goldfish) Dose: 13 mg/l Exposure time: 96 h Acute and prolonged toxicity for aquatic invertebrates: EC50 Species: Daphnia magna (Water flea) Dose: 11.5 mg/l Exposure time: 48 h Toxicity to algae: IC50 Species: Selenastrum capricornutum (green algae) Dose: 12 mg/l Exposure time: 72 h
Cyclohexane	110-82-7	Acute and prolonged toxicity for aquatic invertebrates: EC50 Species: Daphnia magna (Water flea) Dose: 3.78 mg/l Exposure time: 48 h
Pentane	109-66-0	Acute and prolonged toxicity for aquatic invertebrates: EC50 Species: Daphnia magna (Water flea) Dose: 9.74 mg/l Exposure time: 48 h
Heptane [and isomers]	142-82-5	Toxicity to fish: LC50 Species: Carassius auratus (goldfish) Dose: 4 mg/l Exposure time: 24 h

12. ECOLOGICAL INFORMATION

		Acute and prolonged toxicity for aquatic invertebrates: EC50 Species: Daphnia magna (Water flea) Dose: 1.5 mg/l Exposure time: 48 h
1,2,4-Trimethylbenzene	95-63-6	Toxicity to fish: LC50 Species: Pimephales promelas (fathead minnow) Dose: 7.72 mg/l Exposure time: 96 h Acute and prolonged toxicity for aquatic invertebrates: EC50 Species: Daphnia Dose: 3.6 mg/l Exposure time: 48 h
Sulfur	7704-34-9	Acute and prolonged toxicity for aquatic invertebrates: EC0 Species: Daphnia magna (Water flea) Dose: > 10,000 mg/l Exposure time: 24 h

SECTION

Disposal : Dispose of container and unused contents in accordance with federal, state and local requirements.

SECTION

CFR

:
:
:
:

Hazard inducer :

TDG

Proper shipping name :
:
:
:

Hazard inducer :

IATA Cargo Transport

UN UN-No. :

Description of the goods : PETROLEUM DISTILLATES, N.O.S.
(Naphtha; Low boiling point naphtha)

Class :

Packaging group :

ICAO-Labels :

Packing instruction (cargo aircraft) :

Packing instruction (cargo aircraft) :

[illegible]S

IATA Passenger Transport

UN UN-No.	:	
Description of the goods	:	PETROLEUM DISTILLATES, N.O.S. (Naphtha; Low boiling point naphtha)
Class	:	
Packaging group	:	
ICAO-Labels	:	
Packing instruction (passenger aircraft)	:	
Packing instruction (passenger aircraft)	:	

IMDG-Code

UN-No.	:	
Description of the goods	:	PETROLEUM DISTILLATES, N.O.S. (Naphtha; Low boiling point naphtha)
Class	:	
Packaging group	:	
IMDG-Labels	:	
EmS Number	:	
Marine pollutant	:	

SECTION

OSHA Hazards :

Moderate skin irritant
Severe eye irritant
Carcinogen
Teratogen

TSCA Status :

DSL Status : DSL list.

SARA 311/312 Hazards :

Acute Health Hazard
Chronic Health Hazard

SARA III US. EPA Emergency Planning and Community Right-To-Know Act (EPCRA) SARA Title III Section 313 Toxic Chemicals (40 CFR 372.65) - Supplier Notification Required

Components	CAS-No.
1,2,4-Trimethylbenzene	95-63-6
Benzene	71-43-2
Ethylbenzene	100-41-4
Cyclohexane	110-82-7
Toluene	108-88-3
N-hexane	110-54-3
Xylene	1330-20-7

PENN RTK US. Pennsylvania Worker and Community Right-to-Know Law (34 Pa. Code Chap. 301-323)

REGULATORY INFORMATION Canadian

Components	CAS-No.
Heptane [and isomers]	142-82-5
Ethylbenzene	100-41-4
Benzene	71-43-2
1,2,4-Trimethylbenzene	95-63-6
Sulfur	7704-34-9
Pentane	109-66-0
Naphtha; Low boiling point naphtha	8030-30-6
Xylene	1330-20-7
N-hexane	110-54-3
Toluene	108-88-3
Cyclohexane	110-82-7

MASS RTK US. Massachusetts Commonwealth's Right-to-Know Law (Appendix A to 105 Code of Massachusetts Regulations Section 670.000)

Components	CAS-No.
Heptane [and isomers]	142-82-5
Ethylbenzene	100-41-4
Benzene	71-43-2
1,2,4-Trimethylbenzene	95-63-6
Sulfur	7704-34-9
Naphtha; Low boiling point naphtha	8030-30-6
Xylene	1330-20-7
N-hexane	110-54-3
Toluene	108-88-3
Cyclohexane	110-82-7

NJ RTK ct (New Jersey Statute Annotated Section 34:5A-5)

Components	CAS-No.
Heptane [and isomers]	142-82-5
Ethylbenzene	100-41-4
Benzene	71-43-2
1,2,4-Trimethylbenzene	95-63-6
Sulfur	7704-34-9
Naphtha; Low boiling point naphtha	8030-30-6
Xylene	1330-20-7
N-hexane	110-54-3

US. New Jersey Worker and Community Right-to-Know A

Toluene	108-88-3
Cyclohexane	110-82-7

CERCLA SECTION 103 and SARA SECTION 304 (RELEASE TO THE ENVIROMENT)
The CERCLA definition of hazardous substances contains a "petroleum exclusion" clause which exempts crude oil. Fractions of crude oil, and products (both finished and intermediate) from the crude oil refining process and any indigenous components of such from the CERCLA Section 103 reporting requirements. However, other federal reporting requirements, including SARA Section 304, as well as the Clean Water Act may still apply**.**

California Prop. 65 : the State of California to cause cancer.

Ethylbenzene	100-41-4
Benzene	71-43-2

the State of California to cause birth defects or other reproductive harm.

Toluene	108-88-3
Benzene	71-43-2

SECTION

Further information

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

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Revision Date : 01/27/2011

79, 80, 81, 83, 165, 264, 318, 1017, 1018, 1019, 1020, 1021, 1027, 1032, 1055, 1136, 1716

16 OTHER INFORMATION
WARNING! This product contains a chemical known to

ANNEXURE-D

Meteorological Data

जलवायवी सारणी
CLIMATOLOGICAL TABLE

BACK

स्टेशन : जोधपुर (आर.एस./आर.डब्ल्यु.) अक्षांश 26° 18' N देशांतर 73° 01' E समुद्री तल माध्य से ऊंचाई 217 मीटर प्रक्षणों पर आधारित 1968-1990
STATION : Jodhpur (RS/RW) LAT. LONG. HEIGHT ABOVE M.S.L. METRES BASED ON OBSERVATIONS

माह / MONTH		स्टेशन का सतह दाब / STATION LEVEL PRESSURE	वायु तापमान / AIR TEMPERATURE										आर्द्रता / HUMIDITY		मेघ की मात्रा / CLOUD AMOUNTS		वर्षा / RAINFALL						
			माध्य / MEAN						चरम / EXTREMES														
			शुष्क बल्ब DRY BULB	नम बल्ब WET BULB	दैनिक अधिकतम DAILY MAX	दैनिक न्यूनतम DAILY MIN	माह में उच्चतम HIGHEST IN THE MONTH	माह में निम्नतम LOWEST IN THE MONTH	उच्चतम HIGHEST	दिनांक और वर्ष DATE AND YEAR	निम्नतम LOWEST	दिनांक और वर्ष DATE AND YEAR	सापेक्ष आर्द्रता RELATIVE HUMIDITY	वाष्प दाब VAPOUR PRESSURE	समस्त मेघ ALL CLOUDS	निम्न मेघ LOW CLOUDS	मासिक योग MONTHLY TOTAL	वर्षा के दिनांकों संख्या NO. OF RAINY DAYS	वर्षासहित सबसे नम महीने का योग TOTAL IN WETTEST MONTH WITH YEAR	वर्षासहित सबसे शुष्क महीने का योग TOTAL IN DRIEST MONTH WITH YEAR	24 घंटों की सबसे भारी वर्षा HEAVIEST FALL IN 24 HOURS	दिनांक और वर्ष DATE AND YEAR	माध्य पवन गति MEAN WIND SPEED
		एच.पी.ए hPa	डि. से °C	डि. से °C	डि. से °C	डि. से °C	डि. से °C	डि. से °C	डि. से °C		डि. से °C		प्रतिशत %	एच.पी.ए hPa	आकाश के अष्टमाश Oktas of sky		मि.मि. mm		मि.मि. mm	मि.मि. mm	मि.मि. mm		कि.मी. प्र. घं. Kmph
जनवरी JAN	I	990.8	12.8	8.5	24.5	9.3	28.8	5.2	31.0	13	1.8	21	52	7.8	1.8	0.4	1.7	0.2	56.6	0.0	40.1	19	7.1
	II	988.0	23.0	13.4						1979		1978	28	7.9	2.0	0.4			1948			1948	
फरवरी FEB	I	989.3	15.2	10.2	26.9	11.3	32.9	5.2	35.5	24	0.7	07	49	8.8	2.2	0.6	3.8	0.5	48.6	0.0	22.6	28	7.5
	II	986.2	25.6	14.9						1981		1974	26	8.6	2.6	0.8			1906			1939	
मार्च MAR	I	986.6	21.5	14.1	33.3	17.0	38.9	10.4	41.6	31	4.4	09	41	10.2	2.3	0.4	6.0	0.5	100.1	0.0	49.3	25	8.3
	II	983.1	31.8	18.1						1984		1979	21	9.8	2.8	0.7			1967			1967	
अप्रैल APR	I	982.8	27.6	18.3	38.6	22.6	42.6	17.6	45.0	27	16.2	17	37	13.6	1.8	0.2	8.8	0.4	170.6	0.0	156.8	26	9.9
	II	979.0	37.3	21.0						1979		1983	19	11.7	2.5	0.8			1982			1982	
मई MAY	I	979.6	30.2	21.8	41.1	26.2	44.5	21.6	46.3	27	15.4	22	47	19.7	1.1	0.4	16.6	1.1	98.8	0.0	93.0	31	13.0
	II	975.6	39.5	22.5						1973		1983	20	13.8	1.7	1.0			1917			1985	
जून JUN	I	975.5	30.6	24.5	39.9	27.5	44.0	22.8	46.1	18	20.0	10	60	26.1	3.2	1.7	34.1	2.0	183.2	0.0	152.9	17	15.4
	II	971.4	38.4	25.2						1979		1975	33	21.5	3.1	1.9			1917			1917	
जुलाई JUL	I	974.8	28.7	24.8	35.2	26.3	39.9	22.9	42.6	08	21.0	05	73	28.6	5.8	3.4	126.7	5.9	396.5	0.0	194.1	17	13.2
	II	971.4	34.0	25.7						1974		1978	51	26.3	5.6	3.4			1990			1943	
अगस्त AUG	I	976.3	27.6	24.6	33.7	25.2	37.8	22.6	40.3	18	21.2	28	78	28.9	5.8	3.5	121.1	6.2	544.0	0.0	184.4	21	11.3
	II	973.2	32.5	25.7						1974		1978	57	27.8	5.6	3.4			1944			1927	
सितम्बर SEP	I	981.2	27.5	23.2	35.2	23.9	38.6	21.2	42.5	22	18.4	29	69	25.4	3.1	1.8	54.2	2.8	305.1	0.0	215.9	12	8.6
	II	977.8	33.7	24.2						1974		1976	44	22.6	3.5	2.6			1924			1924	
अक्तूबर OCT	I	986.1	25.4	18.6	35.8	20.0	38.7	15.1	40.6	05	12.5	29	50	16.4	1.0	0.4	6.0	0.6	163.1	0.0	142.0	26	6.0
	II	982.9	33.7	20.9						1985		1983	28	14.5	1.8	1.2			1917			1917	
नवम्बर NOV	I	989.9	19.5	13.4	31.1	14.9	34.6	10.0	37.5	03	7.0	27	46	10.6	1.1	0.3	3.1	0.2	40.0	0.0	23.6	20	5.5
	II	986.8	28.2	17.6						1977		1978	30	11.6	1.3	0.4			1981			1976	
दिसम्बर DEC	I	992.0	14.1	9.5	26.5	11.1	30.1	6.7	31.9	01	1.7	29	51	8.3	1.7	0.2	1.5	0.1	28.0	0.0	22.9	18	6.2
	II	988.9	23.9	14.5						1985		1973	30	9.0	2.0	0.3			1980			1937	
वार्षिक योग या माध्य ANNUAL TOTAL OR MEAN	I	983.7	23.4	17.6	33.5	19.6	43.9	5.7	46.3		0.7		54	17.0	2.6	1.1	383.6	20.5	1176.4	37.9	215.9		9.3
	II	980.4	31.8	20.3									32	15.4	2.9	1.4			1917	1918			
वर्षोंकी सं NUMBER OF YEARS	I	21	21	21	15	15	15	15	15		15		21	21	21	22	30	30	90	90	90		15
	II	21	21	21									21	21	21	22							

जलवायवी सारणी
CLIMATOLOGICAL TABLE

स्टेशन : जोधपुर (आर.एस./आर.डब्ल्यु.)
STATION : Jodhpur (RS/RW)

		मौसम परिघटना						पवन														मेघ										दृश्यता				
		के साथ दिनों की संख्या						पवन की गती के साथ दिनों की संख्या (कि. मी. प्र. घं.)				पवन की दिशा के दिनों की संख्या का प्रतिशत										मेघ मात्रा (सभी मेघ) सहित दिनों की संख्या - अष्ठमांश					निम्न स्तरी मेघ मात्रा सहित दिनों की संख्या - अष्ठमांश						दृश्यता सहित दिनों की संख्या				
माह		वर्षण 0.3 मि.मि.या अधिक	ओले	गर्जन	कुहरा	धूल भरी आंधी	चंड वात	62 या अधिक	20-61	1-19	0	उ	उपू	पू	दपू	द	दप	प	उप	शांत	0	ले-2	3-5	6-7	8	0	ले-2	3-5	6-7	8	कुहरा 8	1 कि.मी. तक	1-4 कि.मी.	4-10 कि.मी.	10-20 कि.मी.	20 कि.मी. से अधिक
		WEATHER PHENOMENA						WIND														CLOUD										VISIBILITY				
		No. OF DAYS WITH						No. OF DAYS WITH WIND SPEED (Km. p. h.)				PERCENTAGE No. OF DAYS WIND FROM										No. OF DAYS WITH CLOUD AMOUNT (ALL CLOUDS) OKTAS					No. OF DAYS WITH LOW CLOUD AMOUNT OKTAS						No. OF DAYS WITH VISIBILITY				
MONTH		PPT 0.3 mm Or more	HAIL	THUN DER	FOG	DUST STORM	SQU ALL	62 Or more	20-61	1-19	0	N	NE	E	SE	S	SW	W	NW	CALM	0	T-2	3-5	6-7	8	0	T-2	3-5	6-7	8	FOG 8	UP TO 1 Km.	1-4 Kms.	4-10 Kms.	10-20 Kms.	OVER 20 Kms.
जनवरी	I	0.5	0.0	0.3	0.3	0.0	0.0	0	0	22	9	9	54	6	0	0	1	1	1	28	17	4	5	4	1	28	1	2	0	0	0	0.4	5.3	20.6	4.5	0.2
JAN	II							0	1	22	8	11	30	7	1	1	7	9	8	26	15	4	6	5	1	26	2	3	0	0	0	0.0	1.1	19.1	9.3	1.5
फरवरी	I	0.9	0.0	0.9	0.1	0.1	0.0	0	0	20	8	9	40	10	1	1	4	4	1	30	15	4	5	3	1	24	2	2	0	0	0	0.1	4.1	19.3	4.2	0.3
FEB	II							0	1	22	5	13	19	7	1	1	14	15	12	18	12	4	6	5	1	22	2	4	0	0	0	0.0	0.9	15.7	9.6	1.8
मार्च	I	0.4	0.0	0.4	0.0	0.3	0.0	0	0	22	9	7	26	8	1	5	17	5	3	28	14	5	7	5	0	27	2	2	0	0	0	0.1	4.0	20.6	6.0	0.3
MAR	II							0	3	24	4	7	11	5	1	2	23	24	13	14	11	4	8	7	1	23	3	4	1	0	0	0.4	3.4	15.1	10.4	1.7
अप्रैल	I	1.1	0.0	1.6	0.0	0.7	0.0	0	1	22	7	3	12	6	2	6	36	9	2	24	16	4	7	3	0	28	1	1	0	0	0	0.0	6.3	20.2	3.3	0.2
APR	II							0	3	24	3	4	6	1	0	3	37	28	11	10	12	4	7	6	1	23	3	4	0	0	0	0.5	6.2	15.0	7.5	0.8
मई	I	1.9	0.0	3.5	0.1	1.8	0.0	0	5	23	3	1	4	3	2	6	55	17	3	9	23	2	4	2	0	27	2	2	0	0	0	1.0	9.2	17.7	2.7	0.4
MAY	II							0	8	21	2	2	3	1	1	2	48	32	6	5	17	4	6	3	1	20	5	5	1	0	0	1.8	10.6	14.3	3.7	0.6
जून	I	3.5	0.0	3.7	0.0	2.2	0.0	0	8	20	2	1	1	1	1	4	69	15	1	7	10	3	8	7	2	17	3	8	2	0	0	0.7	10.7	15.9	2.2	0.5
JUN	II							0	8	21	1	3	4	3	2	3	60	18	4	3	11	4	7	6	2	14	5	9	2	0	0	1.7	11.8	13.1	3.0	0.4
जुलाई	I	7.9	0.0	5.7	0.0	0.8	0.0	0	5	24	2	1	1	2	1	4	66	16	1	8	1	2	7	13	8	7	3	14	6	1	0	0.1	6.9	18.9	4.4	0.7
JUL	II							0	5	24	2	1	2	3	4	5	61	15	3	6	2	2	7	14	6	5	4	17	5	0	0	0.4	7.4	16.9	5.1	1.2
अगस्त	I	8.7	0.0	5.2	0.0	0.1	0.0	0	3	24	4	2	1	3	1	4	61	15	1	12	1	2	7	13	8	7	4	13	6	1	0	0.2	2.2	23.3	4.9	0.4
AUG	II							0	4	24	3	2	4	5	2	6	57	12	2	10	1	2	9	14	5	5	5	17	4	0	0	0.1	1.6	21.3	7.3	0.7
सितम्बर	I	3.4	0.0	2.9	0.0	0.2	0.0	0	1	24	5	2	6	4	0	2	48	17	3	18	9	5	7	7	2	17	4	6	3	0	0	0.0	1.4	20.1	7.2	1.3
SEP	II							0	1	25	4	5	7	5	1	4	47	14	4	13	5	6	10	7	2	7	8	12	3	0	0	0.0	1.4	16.6	10.0	2.0
अक्तूबर	I	1.4	0.0	1.0	0.1	0.0	0.0	0	0	15	16	2	14	6	1	2	16	6	1	52	22	3	4	2	0	27	2	2	0	0	0	0.1	3.2	19.8	7.0	0.9
OCT	II							0	1	18	12	4	10	5	1	2	23	11	7	37	16	6	7	2	0	18	6	6	1	0	0	0.1	0.6	16.4	10.4	3.5
नवम्बर	I	0.7	0.0	0.2	0.0	0.0	0.0	0	0	16	14	7	38	5	1	0	1	0	0	48	21	3	3	2	1	27	1	2	0	0	0	0.1	4.4	20.9	4.3	0.3
NOV	II							0	0	13	17	8	17	5	1	1	7	2	4	55	19	4	4	2	1	26	2	2	0	0	0	0.1	0.6	19.0	7.3	3.0
दिसम्बर	I	0.3	0.0	0.1	0.1	0.0	0.0	0	0	21	10	9	50	5	0	0	1	0	1	34	18	5	5	3	0	29	1	1	0	0	0	0.2	4.1	22.4	3.8	0.5
DEC	II							0	0	17	14	9	30	5	0	1	3	4	4	44	16	5	6	4	0	28	2	1	0	0	0	0.1	0.8	20.7	7.5	1.9
वार्षिक योग या माध्य ANNUAL TOTAL OR MEAN	I	30.7	0.0	25.5	0.7	6.2	0.0	0	23	253	89	4	21	5	1	3	31	9	2	25	167	42	69	64	23	265	26	55	17	2	0	3.0	61.8	239.7	54.5	6.0
	II							0	35	255	75	6	12	4	1	3	32	15	7	20	137	49	83	75	21	217	47	84	17	0	0	5.2	46.4	203.2	91.1	19.1
वर्षोंकी सं NUMBER OF YEARS	I	16						21				21									22					22						22				
	II							21				21									22					22						22				

जलवायवी सारणी
CLIMATOLOGICAL TABLE

BACK

स्टेशन : अहमदाबाद अक्षांश 23° 04' N देशांतर 72° 38' E समुद्री तल माध्य से ऊंचाई 55 मीटर प्रक्षणों पर आधारित 1961-1990
STATION : Ahmedabad LAT. LONG. HEIGHT ABOVE M.S.L. METRES BASED ON OBSERVATIONS

माह / MONTH		स्टेशन का सतह दाब / STATION LEVEL PRESSURE	वायु तापमान / AIR TEMPERATURE										आर्द्रता / HUMIDITY		मेघ की मात्रा / CLOUD AMOUNTS		वर्षा / RAINFALL						
			माध्य / MEAN						चरम / EXTREMES														
			शुष्क बल्ब / DRY BULB	नम बल्ब / WET BULB	दैनिक अधिक नम / DAILY MAX	दैनिक न्यून नम / DAILY MIN	माह में उच्चतम / HIGHEST IN THE MONTH	माह में निम्नतम / LOWEST IN THE MONTH	उच्चतम / HIGHEST	दिनांक और वर्ष / DATE AND YEAR	निम्नतम / LOWEST	दिनांक और वर्ष / DATE AND YEAR	सापेक्ष आर्द्रता / RELATIVE HUMIDITY	जल वाष्प दाब / VAPOUR PRESSURE	सकल मेघ / ALL CLOUDS	निम्न मेघ / LOW CLOUDS	मासिक योग / MONTHLY TOTAL	वर्षा के दिनों की संख्या / NO. OF RAINY DAYS	वर्षासहित सबसे नम महीने का योग / TOTAL IN WETTEST MONTH WITH YEAR	वर्षासहित शुष्कतम महीने का योग / TOTAL IN DRIEST MONTH WITH YEAR	24 घंटे की सबसे भारी वर्षा / HEAVIEST FALL IN 24 HOURS	दिनांक और वर्ष / DATE AND YEAR	माध्य पवन गति / MEAN WIND SPEED
		एच.पी.ए hPa	डि. से °C	डि. से °C	डि. से °C	डि. से °C	डि. से °C	डि. से °C	डि. से °C		डि. से °C		प्रतिशत %	एच.पी.ए hPa	आकाश के अष्टमाश Oktas of sky		मि.मि. mm		मि.मि. mm	मि.मि. mm	मि.मि. mm		कि.मी. प्र. घं. Kmph
जनवरी JAN	I	1009.8	14.6	10.8	28.3	11.9	32.2	7.6	36.1	23 1912	3.3	10 1954	59	10.0	1.3	0.1	1.8	0.2	57.4 1948	0.0	30.7	19 1948	5.7
	II	1006.7	26.7	16.7									32	10.9	1.3	0.2							
फरवरी FEB	I	1008.3	17.3	12.4	30.9	14.0	35.2	9.0	40.6	28 1953	2.2	06 1920	53	10.6	1.2	0.2	1.1	0.1	26.4 1917	0.0	26.4	03 1917	6.0
	II	1005.0	29.6	17.5									25	10.5	1.3	0.2							
मार्च MAR	I	1006.1	22.6	16.2	35.8	18.9	39.9	13.3	43.9	31 1908	9.4@	02 1982	49	13.3	1.4	0.1	1.0	0.1	21.1 1967	0.0	15.7	25 1967	6.4
	II	1002.3	34.7	19.7									20	11.0	1.6	0.3							
अप्रैल APR	I	1003.2	27.3	20.8	39.8	23.5	43.1	19.5	46.2	27 1958	12.8	16 1955	54	19.6	1.4	0.2	2.7	0.2	26.4 1947	0.0	21.9	27 1982	7.2
	II	998.9	38.6	22.2									20	13.7	1.8	0.4							
मई MAY	I	1000.6	29.3	24.3	41.7	26.2	44.6	22.8	47.8	27 1916	19.1	27 1974	65	26.4	1.8	1.4	15.1	0.7	230.7 1982	0.0	138.3	09 1982	9.5
	II	995.7	40.4	24.2									23	17.3	1.2	0.7							
जून JUN	I	996.8	29.5	25.9	38.5	27.1	42.4	23.7	47.2	07 1897	19.4	13 1920	74	30.5	4.8	3.2	98.7	4.2	345.8 1980	0.0	131.9	30 1974	10.8
	II	992.4	36.7	26.4									45	26.1	3.9	2.7							
जुलाई JUL	I	995.5	27.5	25.6	33.4	25.6	37.7	23.4	42.2	06 1902	20.4	07 1983	85	31.3	6.5	3.8	262.3	11.2	952.5 1905	3.6 1899	414.8	27 1927	8.9
	II	992.4	31.7	26.6									67	30.6	6.2	3.9							
अगस्त AUG	I	997.2	26.4	24.9	31.9	24.7	35.1	23.0	40.4	16 1987	21.2	12 1984	87	30.3	6.6	3.9	239.6	10.8	609.8 1990	1.0 1899	250.0	30 1976	7.4
	II	994.2	30.3	26.0									71	30.2	6.3	3.8							
सितम्बर SEP	I	1001.3	26.7	24.4	33.7	24.2	37.3	22.0	41.7	29 1951	17.2	25 1972	82	28.8	4.3	2.1	108.9	5.3	636.5 1950	0.0	257.8	17 1950	6.1
	II	997.8	32.3	25.6									58	27.5	4.0	2.5							
अक्तूबर OCT	I	1005.4	25.6	20.9	36.0	21.0	38.4	16.8	42.8	05 1920	12.6	29 1983	64	21.1	1.5	0.4	16.2	0.4	257.0 1985	0.0	166.3	08 1985	4.2
	II	1002.1	33.9	22.9									37	19.2	1.5	0.6							
नवम्बर NOV	I	1008.5	21.3	16.0	33.1	16.6	36.0	12.6	38.9	03 1901	8.3	29 1975	55	14.1	1.4	0.2	11.5	0.6	100.4 1982	0.0	76.8	09 1982	4.4
	II	1005.4	30.4	20.0									35	15.0	1.5	0.4							
दिसम्बर DEC	I	1010.1	16.6	12.5	29.6	13.2	32.6	8.6	35.6	03 1899	3.6	27 1983	60	11.4	1.5	0.1	3.8	0.2	31.2 1980	0.0	29.4	05 1990	5.4
	II	1007.0	27.2	17.7									35	12.8	1.6	0.2							
वार्षिक योग या माध्य ANNUAL TOTAL OR MEAN	I	1003.6	23.7	19.6	34.4	20.6	44.7	6.5	47.8		2.2		66	20.6	2.8	1.3	762.7	34.0	1997.5	119.9	414.8		6.8
	II	1000.0	32.7	22.1									39	18.7	2.7	1.3			1927	1899			
वर्षों की सं NUMBER OF YEARS	I	30	30	30	30	30	30	30	95		95		30	29	30	29	30	30	95	95	95		30
	II	30	30	30									30	29	30	29							

जलवायवी सारणी
CLIMATOLOGICAL TABLE

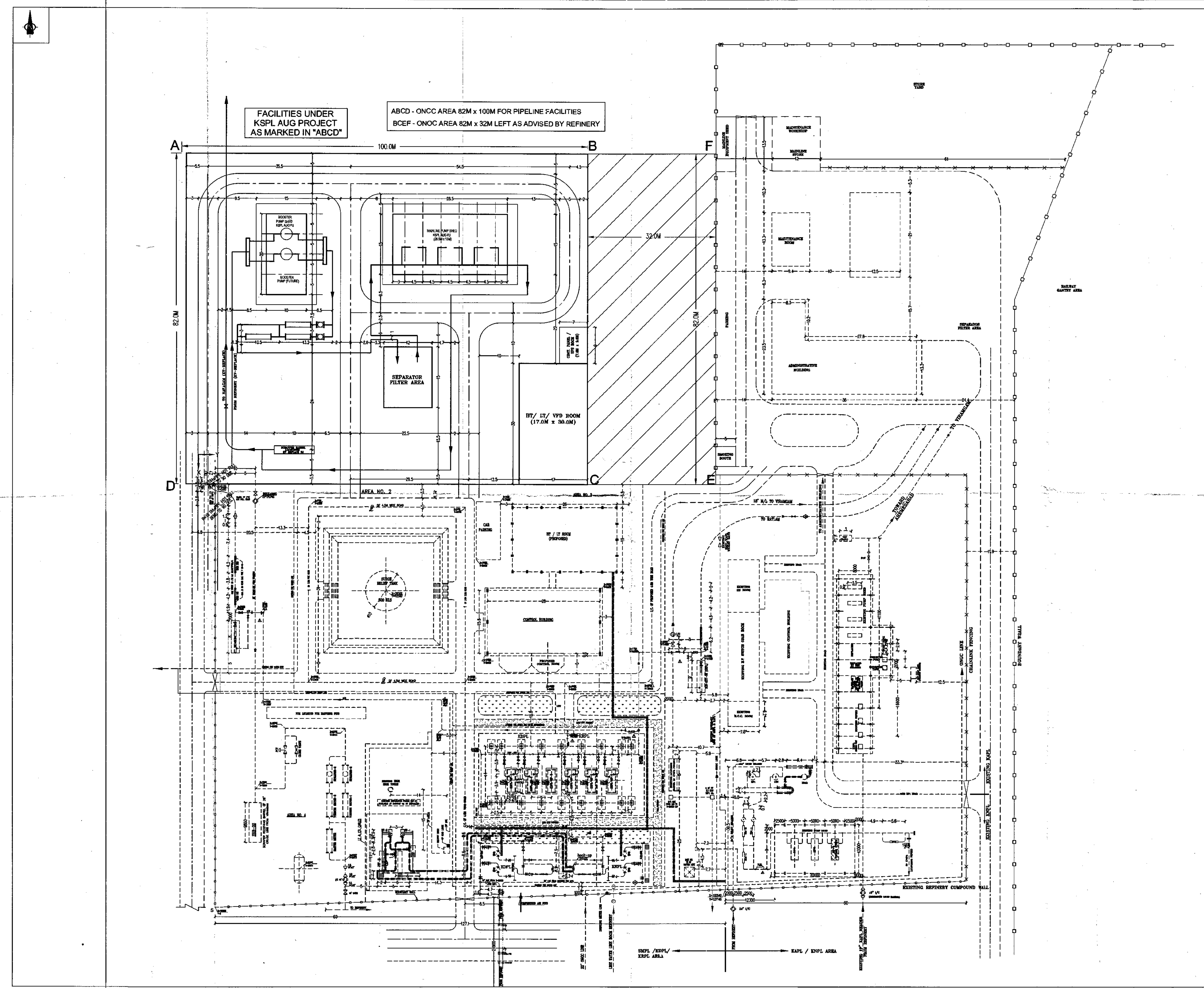
स्टेशन : अहमदाबाद
STATION : Ahmedabad

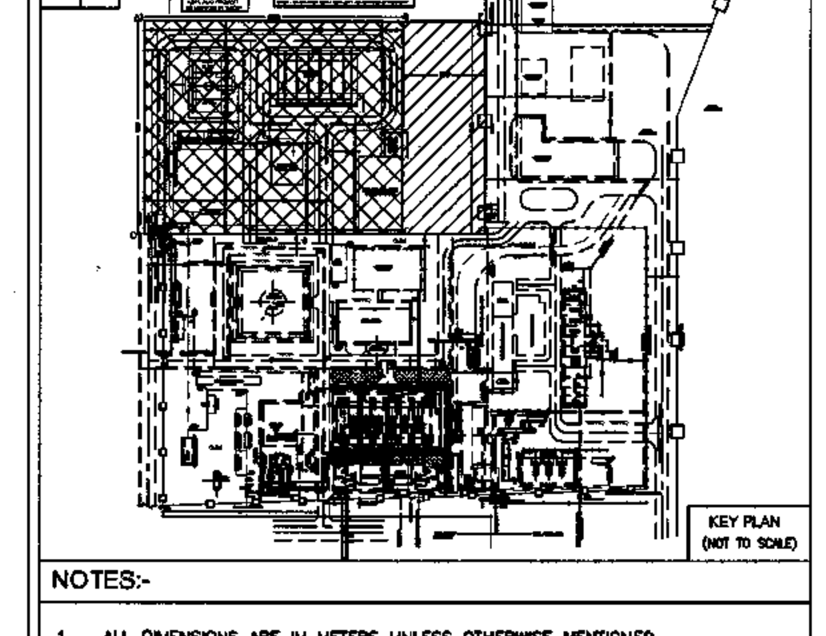
	मौसम परिघटना						पवन														मेघ										दृश्यता				
	के साथ दिनों की संख्या						पवन की गती के साथ दिनों की संख्या (कि. मी. प्र. घं.)				पवन की दिशा के दिनों की संख्या का प्रतिशत										मेघ मात्रा (सभी मेघ) सहित दिनों की संख्या - अष्ठमांश					निम्न स्तरी मेघ मात्रा सहित दिनों की संख्या - अष्ठमांश						दृश्यता सहित दिनों की संख्या				
माह	वर्षण 0.3 मि.मि.या अधिक	ओले	गर्जन	कुहरा	धूल भरी आंधी	चंड वात	62 या अधिक	20-61	1-19	0	उ	उपू	पू	दपू	द	दप	प	उप	शांत		0	ले-2	3-5	6-7	8	0	ले-2	3-5	6-7	8	कुहरा 8	1 कि.मी. तक	1-4 कि.मी.	4-10 कि.मी.	10-20 कि.मी.	20 कि.मी. से अधिक
	WEATHER PHENOMENA						WIND														CLOUD										VISIBILITY				
	No. OF DAYS WITH						No. OF DAYS WITH WIND SPEED (Km. p. h.)				PERCENTAGE No. OF DAYS WIND FROM										No. OF DAYS WITH CLOUD AMOUNT (ALL CLOUDS) O K T A S					No. OF DAYS WITH LOW CLOUD AMOUNT O K T A S						No. OF DAYS WITH VISIBILITY				
MONTH	PPT 0.3 mm Or more	HAIL	THUN DER	FOG	DUST STORM	SQU ALL	62 Or more	20-61	1-19	0	N	NE	E	SE	S	SW	W	NW	CALM		0	T-2	3-5	6-7	8	0	T-2	3-5	6-7	8	FOG 8	UP TO 1 Km.	1-4 Kms.	4-10 Kms.	10-20 Kms.	OVER 20 Kms.
जनवरी I	0.4	0.0	0.2	0.4	0.0	0.0	0	1	22	8	13	25	26	1	1	0	2	7	25		18	7	3	3	0	30	1	0	0	0	0	0.6	4.5	21.0	4.9	0.0
JAN II							0	2	27	2	30	17	13	3	1	3	5	23	5		19	6	4	2	0	28	2	1	0	0	0	0.0	0.1	7.2	22.3	1.4
फरवरी I	0.3	0.0	0.2	0.2	0.1	0.0	0	1	19	8	10	19	19	2	0	1	4	17	28		18	4	3	3	0	26	1	1	0	0	0	0.3	3.8	19.5	4.4	0.0
FEB II							0	2	25	1	22	12	9	2	3	5	13	30	4		17	5	3	3	0	25	2	1	0	0	0	0.0	0.2	4.2	22.6	1.0
मार्च I	0.3	0.0	0.4	0.1	0.0	0.1	0	1	24	6	9	9	12	3	2	2	9	33	21		17	6	5	3	0	29	1	1	0	0	0	0.1	2.9	20.1	7.9	0.0
MAR II							0	3	27	1	16	7	4	2	3	8	21	35	4		16	6	6	3	0	27	2	2	0	0	0	0.0	0.4	4.2	24.7	1.7
अप्रैल I	0.3	0.0	0.5	0.0	0.0	0.0	0	2	25	3	8	2	4	1	2	7	17	50	9		17	6	4	3	0	28	1	1	0	0	0	0.1	1.4	15.6	12.9	0.0
APR II							0	4	25	1	11	1	1	1	3	12	30	37	4		15	7	5	3	0	25	4	1	0	0	0	0.0	0.5	4.2	23.7	1.6
मई I	0.8	0.0	1.4	0.0	0.2	0.2	0	3	27	1	2	0	1	1	6	24	33	30	3		15	5	7	4	0	19	4	6	2	0	0	0.0	0.9	15.5	14.6	0.0
MAY II							0	8	22	1	3	1	1	1	8	25	38	21	2		16	9	5	1	0	19	9	3	0	0	0	0.1	1.0	5.3	23.2	1.4
जून I	6.1	0.0	3.5	0.0	0.5	0.9	0	2	26	2	1	0	1	4	13	42	26	7	6		2	4	10	11	3	5	7	13	5	0	0	0.0	1.1	17.8	11.1	0.0
JUN II							0	9	20	1	1	0	1	4	24	37	23	6	4		2	7	11	8	2	4	10	14	2	0	0	0.1	1.4	8.1	19.8	0.6
जुलाई I	15.8	0.0	4.9	0.0	0.1	0.3	0	2	26	3	1	0	1	4	12	47	21	5	9		0	1	6	14	10	1	6	18	6	0	0	0.0	3.2	21.1	6.6	0.1
JUL II							0	6	23	2	1	1	1	5	17	38	23	6	8		0	1	7	16	7	0	5	21	5	0	0	0.0	1.5	12.8	16.2	0.5
अगस्त I	16.9	0.0	3.4	0.1	0.0	0.1	0	1	27	3	0	0	0	1	8	45	28	9	9		0	1	4	15	11	2	6	16	7	0	0	0.2	2.7	22.2	5.9	0.0
AUG II							0	2	26	3	1	0	0	3	12	37	28	9	10		0	1	6	17	7	0	7	19	5	0	0	0.1	1.3	12.7	16.5	0.4
सितम्बर I	7.5	0.0	2.8	0.1	0.0	0.4	0	1	25	4	3	2	2	3	6	18	26	27	13		3	5	8	11	3	11	6	10	3	0	0	0.0	2.2	15.9	11.8	0.1
SEP II							0	1	25	4	6	3	3	4	8	23	22	16	15		2	8	10	8	2	4	13	11	2	0	0	0.1	0.6	7.3	20.7	1.3
अक्तूबर I	1.1	0.0	0.8	0.2	0.0	0.0	0	0	20	11	9	8	16	6	1	2	4	18	36		16	7	5	3	0	27	2	1	1	0	0	0.1	1.3	16.2	13.3	0.1
OCT II							0	0	23	8	14	11	9	6	4	7	6	16	27		14	10	5	2	0	20	9	2	0	0	0	0.0	0.1	4.9	22.9	3.1
नवम्बर I	0.9	0.0	0.2	0.0	0.0	0.0	0	1	20	9	8	21	36	3	1	0	0	2	29		17	6	4	2	1	28	1	1	0	0	0	0.1	2.4	19.9	7.5	0.1
NOV II							0	0	22	8	18	16	17	5	2	2	3	10	27		16	6	4	3	1	24	4	2	0	0	0	0.0	0.1	7.4	20.8	1.7
दिसम्बर I	0.3	0.0	0.2	0.1	0.0	0.0	0	1	23	7	10	24	38	2	0	0	0	3	23		17	6	5	3	0	30	1	0	0	0	0	0.1	3.5	20.7	6.7	0.0
DEC II							0	1	25	5	23	16	19	3	2	1	3	16	17		16	7	5	3	0	28	2	1	0	0	0	0.0	0.2	9.6	20.0	1.2
वार्षिक योग या माध्य I	50.7	0.0	18.5	1.2	0.9	2.0	0	16	284	65	6	9	13	3	4	16	14	17	18		140	58	64	75	28	236	37	68	24	0	0	1.6	29.9	225.5	107.6	0.4
ANNUAL TOTAL OR MEAN II							0	38	290	37	12	7	7	3	7	17	18	19	11		133	73	71	69	19	204	69	78	14	0	0	0.4	7.4	87.9	253.4	15.9
वर्षोंकी सं I	30						30				30										29					29						29				
NUMBER OF YEARS II							30				30										29					29						29				

ANNEXURE-E

Plant Layouts

Plant Layout: Koyali Station





NOTES:-

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE MENTIONED.
2. PIPING SNOWN HERE SHALL BL OONFIRMED AS PER RESPECTIVE ASSEMBLY PIPING AREA DRAWING.
3. THIS DRAWING HAS BEEN PREPARED BASED ON DRAWING NO. KHPL/MECH/KOY/1964

LEGEND :-

——————	PROPOSED PIPING & FACILITIES (KSPL AUG PJ)
– – – – – –	EXISTING PIPING & FACILITIES

S.NO.	REFERENCE DRAWING	DWG. NO.

PURPOSE

NO.	DATE	DRAWN INI.	DRAWN SIG.	DESIGNED INI.	DESIGNED SIG.	CHECKED INI.	CHECKED SIG.	APPROVED INI.	APPROVED SIG.	SUBJECT OF REVISION
00	16.03.16	ghk		GS		CIVIL / ELEC / MECH		KK		

इंडियन ऑयल कॉर्पोरेशन लिमिटेड (पाइपलाइन्स)
INDIANOIL CORPORATION LIMITED (PIPELINES)

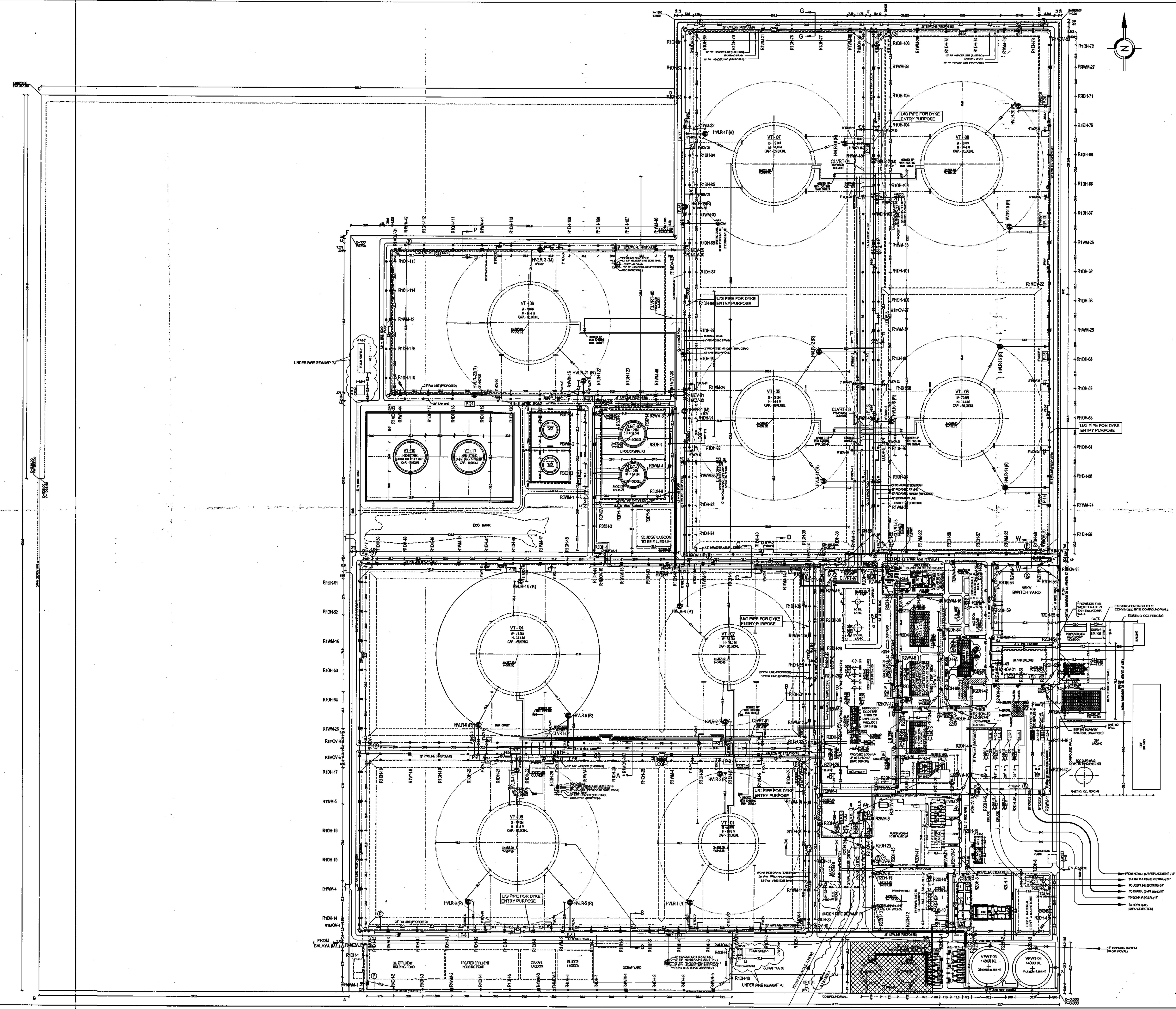
KOYALI - SANGANER AUGMENTATION PIPELINE PROJECT

GENERAL LAYOUT PLAN AT KOYALI FOR KSPL AUG PROJECT

CAD FILE NO.	DWG. NO.	SCALE	SIZE	SHEET
KSPL AUG-16-00	9200-10301-302-001-00	1:350	A1	1 OF 1

N-22006 ICCL A-1 841 X 594

Plant Layout: Viramgam Terminal



NOTE:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE MENTIONED.
2. FOR DETAILS OF FIRE FIGHTING PIPING LAYOUT NEAR PROPOSED FIRE WATER TANKS & NEW FIRE WATER PUMP SHED, REFER ASSEMBLY PIPING AREA DRAWING FOR FIRE FIGHTING PUMP SHED (DWG. NO: 9200-03203-402-101-00 SHEET 1 OF 3, 2 OF 3 & 3 OF 3)
3. EXTENSION OF EXISTING FIRE WATER NETWORK TO AND AROUND PROPOSED LBT TANKS AND FILLING OF FIRE WATER POND-2 IS ALSO UNDER THE SCOPE OF FIRE FIGHTING WORKS.
4. DISMANTLING OF EXISTING WORKSHOP BLDG. IS ALSO ALSO UNDER THE SCOPE OF NEW WORKSHOP BUILDING WORKS.
5. LOCATION AND SIZE OF HT/ VFD / LT / X'MER ROOM MAY CHANGE DURING DETAILED ENGINEERING AFTER RECIEPT OF ENGINEERING DRAWINGS FROM VENDOR.
6. WORKSHOP/FIRE STATION ARE TO BE LOCATED AS PER APPROVED LOCATION AT SITE.
7. EXISTING FIRE WATER LINE TO BE RE-ROUTED IF FOULING WITH THE PROPOSED FACILITIES.

LEGEND:

PROPOSED PIPELINE
PROPOSED FIRE WATER NETWORK
EXISTING FIRE WATER NETWORK
EXISTING FACILITIES
PROPOSED FACILITIES
EXISTING FACILITIES TO BE DISMANTLED
PROPOSED SMPL DBNK FACILITIES

S.NO.	REFERENCE DRAWING	DWG. NO.

PURPOSE: DFR

NO.	DATE	DRAWN INI.	DRAWN SIG.	DESIGNED INI.	DESIGNED SIG.	CHECKED INI.	CHECKED SIG.	APPROVED INI.	APPROVED SIG.	SUBJECT OF REVISION
00	21.10.13	SRS		RS		LM		HKS		

इंडियन ऑयल कॉर्पोरेशन लिमिटेड (पाइपलाइन्स)

INDIAN OIL CORPORATION LIMITED (PIPELINES)

KANDLA VIRAMGAM REVERSE PUMPINGPROJECT

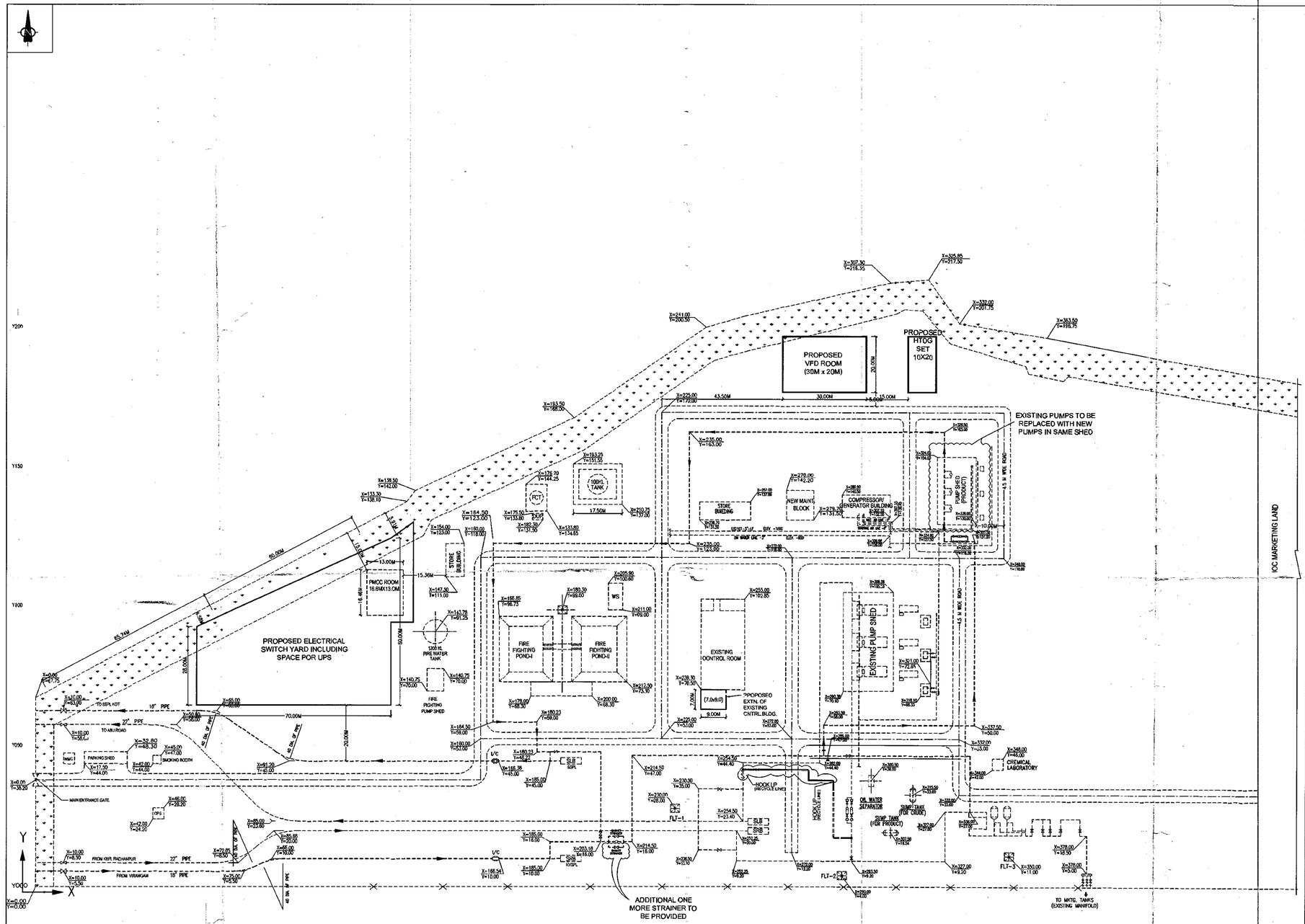
GENERAL LAYOUT PLAN OF VIRAMGAM PUMP STATON

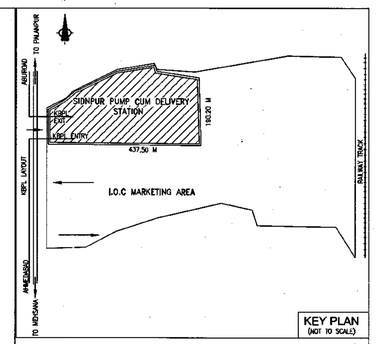
CAD FILE NO	DWG. NO.	SCALE	SIZE	SHEET
KVRPL-05-00	9200-09505-202-001-00	1:1250	A1	1 OF 1

N-19122

ICCL A-1 841 X 594

Plant Layout: Sidhpur Station





KEY PLAN
(NOT TO SCALE)

LEGEND:

PROPOSED FACILITIES	
EXISTING FACILITIES	
EXISTING ROAD	

NOTES:-

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE MENTIONED

PROPOSED FACILITIES

EXISTING FACILITIES

S.NO.	REFERENCE DRAWING	DWG. NO.
1.	GENERAL LAYOUT PLAN FOR SIDHPUR PUMP STN	9200-04602-402-01-00

PURPOSE: TENDER

NO.	DATE	REVISION	DRAWN	DESIGNED	CHECKED	APPROVED	SUBJECT OF REVISION
00	18.03.16	FIRST	GS	CIVIL / MECH / E&I	KK		

इंडियन ऑयल कॉर्पोरेशन लिमिटेड (पाइपलाइन्स)
IndianOil INDIANOIL CORPORATION LIMITED (PIPELINES)

KOYALI – SANGANER AUGMENTATION PIPELINE PROJECT

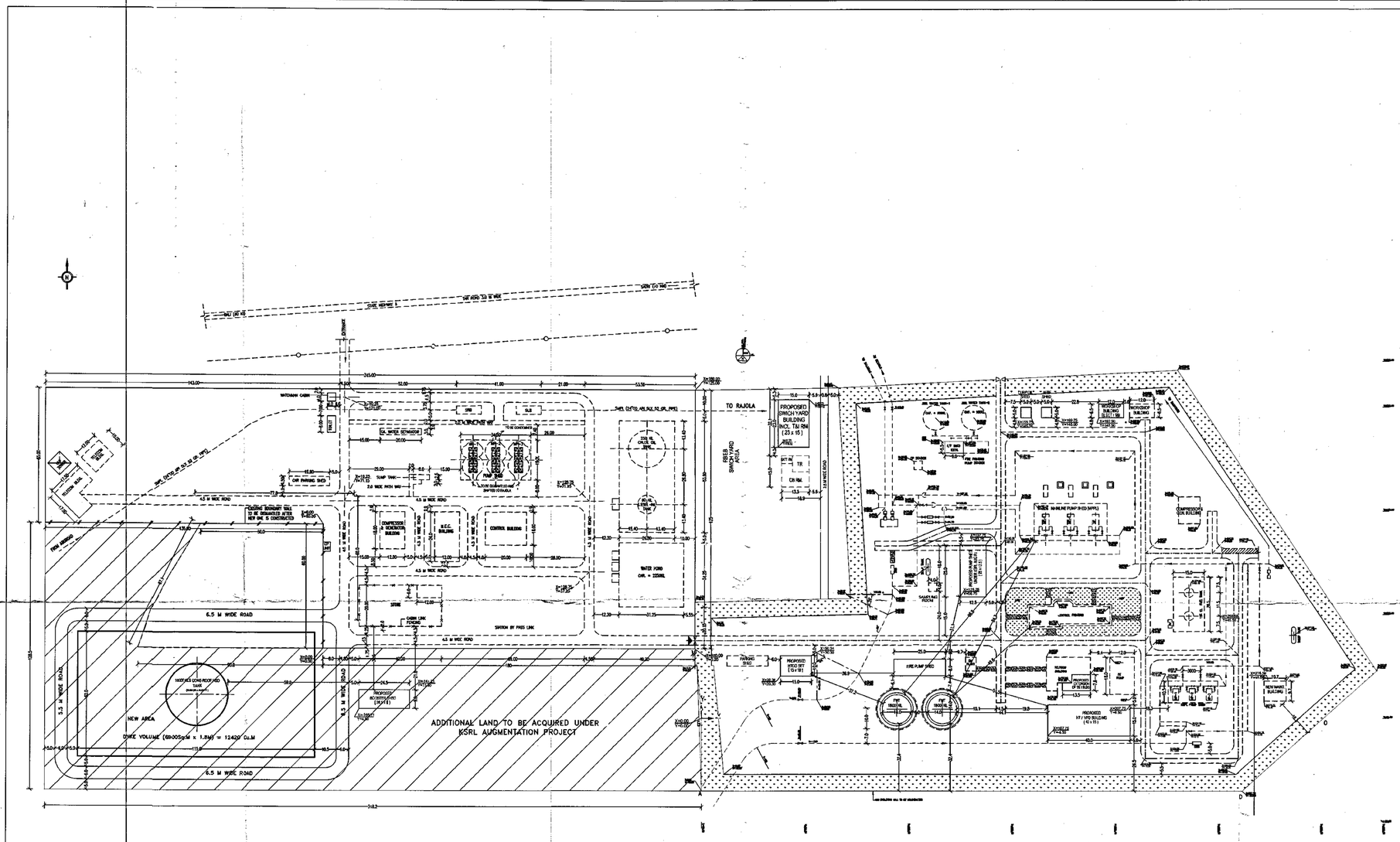
GENERAL LAYOUT PLAN FOR SIDHPUR PUMP STATION

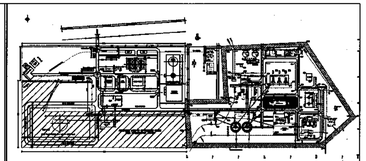
CAD FILE NO.	DWG. NO.	SCALE	SIZE	SHEET
KSPL-1-00	9200-10305-302-001-00	1:750	A1	1 OF 1

N-8223

IOCL A-1 841 x 594

Plant Layout: Kot Station





KEY PLAN
(NOT TO SCALE)

LEGEND:

PROPOSED FACILITIES

EXISTING FACILITIES

EXISTING FACILITIES TO DISMANTLE

S.NO.	REFERENCE DRAWING	DWG. NO.

PURPOSE: FOR TENDER PURPOSE ONLY

NO.	DATE	INI.	SIG.	INI.	SIG.	INI.	SIG.	INI.	SIG.	SUBJECT OF REVISION
00	18.03.16	ghk		AA	AKS	CIVIL / ELEC / MECH		KK		
REVISION		DRAWN		DESIGNED		CHECKED		APPROVED		

इंडियन ऑयल कॉर्पोरेशन लिमिटिड (पाइपलाइन्स)
Indian Oil Corporation Limited (Pipelines)

KOYALI - SANGANER PIPELINE AUGMENTATION PROJECT

GENERAL LAYOUT PLAN FOR KOT PUMP STATION (KSPL AUG PJ)

CAD FILE NO.	DWG. NO.	SCALE	SIZE	SHEET
KSPL AUG-35-00	9200-10307-302-001-00	1:700	A1	1 OF 1

N-22351

IOCL A-1 841 X 594