Chapter -7

Additional Studies

7.1 R & R ACTION PLAN

There is no R & R action plan because proposed expansion shall be taken up in existing Sugar Factory & Co-gen Plant of JSSSKL located at Hupari, Maharashtra.

7.2 POTENTIAL AND MAJOR HAZARDS IN SUGAR FACTORY

Process for manufacturing and refining sugar is a standard process. Risk assessment and hazard management study for expansion of sugar factory from 12,000 TCD to 16,000 TCD by **Mr. Vinod Sahasrabuddhe** who is FAE for RH in respect of EEIPL. Areas of concern from hazard and risk points of view in the plant manufacturing of sugar are as follows-

7.3 OBJECTIVES AND SCOPE OF THE RH REPORT:

7.3.1 Objective of the Risk and Hazard analysis

1) Identify hazards and nature of hazard in the process, storage and handling of hazardous chemicals.
2) Carry out Qualitative risk analysis for the process and suggest mitigation measures.
3) Carry out Quantitative risk analysis of the storage of hazardous chemicals and estimate the threat zones for Most Credible and Worst case scenarios
4) Suggest mitigation measures to reduce the risk/probability of the accident to the minimum.
5) Incorporate these measures for ensuring safe operations and safe layout to mitigate hazard and for effectively encounter any accident reduce the damages to the minimum.
6) Suggest Guidelines for on-site and off - site emergency plan

7.3.2 Methodology

7.3.2.1 Identify hazards based on

- Processes description based.
- Hazardous Chemicals handled and stored.
- Inventory of Hazardous chemicals

7.3.2.2 Hazard Assessment

- By Qualitative Risk Assessment
- By Quantitative Risk Assessment by Hazard index calculations and estimate threat zones by using ALOHA

7.3.2.3 Recommendations

- Recommend mitigation measures based upon the above
- Recommending guidelines for the preparation of On-site Emergency plan.

7.4 HAZARD IDENTIFICATION IN SUGAR INDUSTRY:

Potential hazardous areas and the likely accidents with the concerned area have been enlisted below-

Table 7.1 Possible Hazardous Locations onsite

No.	Hazardous Area	Hazard identified	Mitigation measures	Mitigation measures in place /have to be in place for running plant	Comments/ Additional measures
1	Boiler Area	Explosion	IBR rules for design, maintenance and operation of boilers by certified boiler attendants in mandatory	These measures are in place as the boiler is in operation for the existing capacity.	Will be adopted for the additional boiler capacity
2	All over the plant	Lightening	To design and install adequate number of best available lightening arrestors.	These measures are in place as the boiler is in operation for the existing capacity.	If additional are required for increased area of operations these will be installed
3	Electrocution	Lose fitting	Regular maintenance, internal safety audit, and external safety audit at regular intervals.	These are in place for the operation of the existing capacity	
4	Electrical rooms	Fire and electrocution	Regular maintenance, internal safety audit, and external safety audit at regular intervals.	These are in place for the operation of the existing capacity	
5	Transformer area	Fire and electrocution	Regular maintenance, internal safety audit, and external safety audit at regular intervals.	These are in place for the operation of the existing capacity	
6	Cable tunnel	Fire and electrocution	Regular maintenance, internal safety audit, and external safety audit at regular intervals.	These are in place for the operation of the existing capacity	

7.4.1 Mitigation Measures to avoid accidents

Preventive Measures for Electricity Hazard

- All electrical equipment is to be provided with proper earthing. Earthed electrode are periodically tested and maintained.
- Emergency lighting is to be available at all critical locations including the operator's room to carry out safe shut down of the plant.
- Easy accessibility of fire fighting facilities such as fire water pumps and fire alarm stations is considered.
- All electrical equipments to be free from carbon dust, oil deposits, and grease.
- Use of approved insulated tools, rubber mats, shockproof gloves and boots, tester, fuse tongs, discharge rod, safety belt, hand lamp, wooden or insulated ladder and not wearing metal ring and chain.
- Flame and shock detectors and central fire announcement system for fire safety are to be provided.
- Temperature sensitive alarm and protective relays to make alert and disconnect equipment before overheating is to be considered
- Danger from excess current due to overload or short circuit is to be prevented by providing fuses, circuit breakers, thermal protection

7.5 BOILER SECTION

Presently Three boilers of capacities 75 TPH, 90 TPH & 20 TPH are installed on site. The working pressure and temperature of 75 TPH boiler & 90 TPH boiler is 47 kg/cm^2 & 485^{0}C. 20 TPH boiler is operated at 20 kg/cm^2 pressure & 320^{0}C temperature. Boiler ash after the ESP is directly stored in tractor and transported to brick manufacturers. Wet Boiler ash was handled and loaded manually into the tractors to be sold to brick makers. The workers should be providing with them proper clothing and soap etc for cleaning, after their duty.

7.5.1 Establishing a Fire Fighting Group

A small spark of fire may result into loss of lives, machines and the damage by fire may result in high economic losses. This type of losses can be avoided by preventing and controlling the fire instantly for which fire–fighting group will be established. Fire fighting group would house and keep in readiness, the following types of equipment and arrangements. Fire extinguisher details along with layout are enclosed in **Appendix J.**

- CO_2 extinguishers
- Dry powder chemical extinguishers
- 80 mm. spray hoses
- Fire brigade

7.6 Hazard Identification: Sugar Manufacturing Section

Amongst the hazards identified above the area of major concern for fire, explosion and exposure to and release of toxic liquids and gases and there is risk of persons, outside the factory limits getting affected are identified below:

i. Bagasse storage: Fire hazard
ii. Production and handling of SO_2
iii. Molasses Storage tanks: Leakage of molasses due to tank failure

7.6.1 Bagasse Production and Storage

7.6.1.1 Present Scenario

At present capacity for 12000 TCD capacity plant, 108000 MTPM of Bagasse is produced. **1992 MT/D** is consumed in the boiler as fuel and is stored in a storage yard. **Present Baggase storage area is 31000 Sq. M is provided** and the same will be used after expansion.

Present scenario of safety measures

There is fire hydrant piping laid around the Baggase storage area. Fire hydrant system is provided and maintained to cover up entire baggase yard.

Suggested measure

1. The fire- hydrant system has to be continuously charged with water pressure of 2 Kg/sq.cm.
2. Hydrant points must be always approachable, even during night.
3. Fire hose and boxes have to be in good ready to use condition.

Following mitigation measures will be in place for Fire fighting in the baggase storage yard during the implantation of expansion.

It will be ensured that piping hydrant system will be laid around the entire baggase storage and will be designed as per relevant IS standard. With minimum following requirements:

- There is enough water storage and it will be ensured that more than adequate water storage for required after expansion will be available for firefighting as per the relevant IS standard.
- Water storage provision of to be exclusively used for fire fighting has been made is as per IS 9668.
- Hydrants will be located at a suitable distance from the boundary of baggase storage area, but not more than 15 Meters away.
- Minimum 7kg/sq.cm water pressure will be available at the farthest hydrant point.
- Hydrants, single headed or double headed will be installed at every 30 Meters or as per the relevant IS standards.
- Fire NOC will be obtained before the startup.
- Fire- hydrant system has to be continuously charged with water pressure of 7 Kg/sq.cm.
- Hydrant points must be always approachable, even during night.
- Fire hose and boxes have to be in good ready to use condition.

Fire fighting system for the present plant

1. The company has adequate water storage reserved for fire fighting, main fire hydrant pump, pump running on HSD, alarm system.
2. Water storage for Firefighting 2750 Cu. M
3. Hydrant points - 24
4. Main Hydrant pump Capacity – 55.56 Cu. M/sec

Recommendations:

Fire NOC may be required now and/or before distillation plant commissioning.

7.6.1.2 Additional Mitigation Measures for safe storage

Following mitigation measures to eliminate the fire hazard are in place and some additional measures are suggested as below:

1. It should be ensured while routing high tension voltage lines to avoid storage of bagasse storage below & near high voltage (H.T.) transmission lines.
2. Avoid routing of electric supply cables & cable trenches near to bagasse storage and if unavoidable locate these as far away from stored bagasse or bagasse heaps.
3. Always keep other raw materials & useful material far away from storage of bagasse area.
4. Creating awareness among workers about sudden bagasse fire and emergency action plan will definitely avoid risks of heavy fire. In this way we can save a valuable fuel & life of human being working near bagasse.
5. Posting of proper supervision staff with necessary communication facility.
6. Hot work, like welding, gas cutting should not be carried out near Bagasse storage. Or only after issue of proper work permit and making necessary arrangements.
7. Daily record of Bagasse storage data must be maintained and proper review of storage conditions must be taken by higher authority.
8. Training of all the involved staff in firefighting in normal & emergency operating system.
9. Proper Planning & Maintenance of the fire hydrant system around the bagasse storage yard and not depending exclusively on fire tender for fire fighting.

10. Creating awareness among workers about sudden bagasse fire and emergency action plan will definitely avoid risks of heavy fire. In this way we can save a valuable fuel & life of human being working near bagasse.
11. Goggle and mask should be provided for workers in bagasse yard to prevent ill effect on eyes and inhalation of fine Bagasse dust on the workers in the area.

7.6.2 Hazard Identification : Sulphur Storage

At present sulphur is stored in a closed shed. The storage capacity of sulphur at site is 500 MT but presently only 150 MT sulphur is stored. The same storage would be used after the expansion. There are no electrical connections /lighting points inside the Sulphur warehouse. And it was informed that all Sulphur required is transferred to the SO_2 generation site during daytime only. Special design features included in sugar juice sulphiter to ensure complete absorption of SO_2. The details of absorption / scrubber system installed to sulphiter with zero discharge of SO_2 into the atmosphere.

Following are the hazards in storage and handling Sulphur.

1. Dust Explosion
2. Fire

7.6.2.1 Dust Explosion

As Sulphur is stored and handled in granular form, there is always some dust formation, which can lead to dust explosion. A dust explosion occurs when a fine dust in suspension in air is ignited, resulting in a very rapid burning, and the release of large quantities of gaseous products. This in turn creates a subsequent pressure rise of explosive force capable of damaging plant and buildings and injuring people. It is generally considered that a dust explosion can only be initiated by dust particles less than 500 microns diameter.

CONDITIONS FOR A DUST EXPLOSION

Following conditions are necessary before a dust explosion can take place.

a) The dust must be combustible.
b) The dust cloud must be of explosive concentration, i.e. between the lower and upper explosion limits for the dusts. Sulphur is a flammable substance in both the solid and liquid states. The dust is characterized by a very low ignition point of 190°C compared to other combustible dusts, and dust clouds are readily ignited by weak frictional sparks. Dusts containing 25% or more elemental Sulphur may be almost as explosive as pure sulphur.
c) There must be sufficient oxygen in the atmosphere to support and sustain combustion.
d) A source of ignition must be present.
e) The dust must be fine enough to support an explosion.

7.6.2.2 Mitigation Measures

Explosion Prevention: Dust explosions can be prevented by ensuring that the following conditions are met

- **Formation and Suspensions of Sulphur dust in air are avoided**

a. To prevent dust formation during the storage and handling of Sulphur, it is necessary to take necessary precautions to avoid spillage and crushing of granular Sulphur during bulk loading and unloading in the storage area.
b. Storage shed should be constructed with a minimum number of horizontal surfaces to avoid dust must accumulation.
c. Bulk accumulations of fine Sulphur may also be removed using soft push brooms, having natural bristles and non-sparking scoops or shovels before vacuum cleaning equipment is used.
d. The use of compressed air to remove dust from any surface, vigorous sweeping or any other method of cleaning which may raise a dust cloud is prohibited.
e. All sources of ignition are excluded.
f. Presence of moisture helps in preventing dust explosion.

7.6.2.3 Fire in Sulphur storage

There is a risk of fire in Sulphur storage as ignition temperature is low 190 deg C. Solid and liquid Sulphur will burn to produce Sulphur dioxide gas, which is extremely irritating and toxic. The effects of the fire hazard itself are slight.

7.6.2.4 Mitigation Measures

- Smoking and the use of matches shall be prohibited in all areas where Sulphur dust is likely to be present. Prominent NO SMOKING signs shall be placed around such areas.
- Naked flames or lights and the use of gas cutting or welding equipment is prohibited during the normal operation of the plant. Repairs involving the use of flames, heat, or hand or power tools in areas where sulphur may be present shall be made only after getting hot work permit from the authorities.
- Where this is not possible the sulphur shall be wetted down.

7.6.2.5 Safety and fire fighting tips

- Always use Self Contained Breathing Apparatus (SCBA). Sulphur fires produce hazardous sulphur dioxide gas. Sulphur dioxide gas is heavier than air and will accumulate in the vapour spaces of the rail car.
- Automatic sprinkler systems which comply with relevant Indian Standards and provide a fine spray or mist are recommended as the most satisfactory extinguishing system for bulk stores. Fire hoses and extinguishers must be fitted with fine spray nozzles to ensure that Sulphur dust clouds are not raised, as these can explode on contact with the fire.
- Small Sulphur fires are easily extinguished by adding more sulphur on top of the burning Sulphur. This depletes the oxygen and smothers the fire.
- For larger Sulphur fires use a light water fog or CO_2 to extinguish. Do not use heavy water streams as this may create Sulphur dust which could potentially explode.

7.6.3 Hazard Identification : Molasses Storage

There are following areas of concern are:
Molasses storage: Heavy leakage of Molasses, total breakage of tank, leading to loss of life and pollution.

7.6.3.1 Present Scenario

Five numbers of molasses tanks having capacities of 6000 MT are installed for storage of molasses. Cooling system for tank is provided for safety purpose. There is gutter provision made around the tank for collection of molasses in accidental leakage.

7.6.3.2 Mitigation Measures

It is necessary to take following mitigation measures to prevent bursting of tanks, and heavy leakage and loss of life.

Storage of molasses

1. Molasses should be stored in good quality and leak proof mild steel tanks.
2. Adequate safety factor should be incorporated into the design of wall thickness considering deterioration that will occur due to corrosion over a period of time.
3. Regular internal and external inspection should be scheduled for checking wall thickness of the tanks. At present there is no dyke wall around Molasses storage tanks.
4. Dyke/ Bund walls should be constructed around the tank or tanks.
5. It must be ensured while finalizing the dyke dimensions and that thickness that clear volume inside the dyke walls is equal or more than 1.2 x volume of tank storage capacity.
6. Continuous mixing of molasses through external pump circulation should be done.
7. If there is increase in temperature beyond 30^0C external cooling of tanks shall be provided by heat exchanger in the circulation line.
8. Frequent Temperature monitoring, manually or by recorder is strongly advised.
   If there is leakage –
   a. Leakage should be washed out and diluted and should be recycled as far as possible or must be properly treated in Effluent treatment plant.
   b. Replacing of leaky gaskets, joints, should be done strictly by following work permit system.
   c. Leakage of pipelines, welding repairs should be attended / carried out outside the plant. The necessary hot work permit should be issued after taking necessary precautions and fire fighting measures for onsite hot work, by the concerned authority before any hot work in undertaken
   d. Leakage through pump gland shall be reduced to the minimum by installing mechanical seals.
   e. To attend all major leakage in tanks the following procedure should be followed
      (i) Transfer the material to other tank.
      (ii) Prepare the tank for welding repairs by making sure that it is positively isolated with blinds from other vessels and ensuring that it is free of the chemicals and gases by purging air and carrying out air analysis before any hot work is undertaken and this should be done by skilled workers. For this purpose safety permit should be given.

7.6.4 Hazard Identification : Sulphur di-oxide (SO_2) production and handling

Plant has standard SO_2 production unit. It was confirmed that the existing production capacity is adequate to cater to the additional requirement of Sulphur di oxide (SO_2) for increased production. However, if this is found not adequate, the capacity will have to be increased. The unit produces required amount of Sulphur dioxide (SO_2) at the required rate by changing sulphur feed to the unit, it is melted at 150 deg C and charged to the burner chamber, where in the air at controlled rate is fed to burner to produce Sulphur di oxide (SO_2). Gas at high

temp of 400 to 600 deg C is cooled to first to 90 deg C and then 60 deg C and sent to the user unit through 100 mm piping at 1.5 to 1.7 atm pressure. This is unit designed for insitue production and use of Sulphur dioxide (SO_2). There is practically no inventory of gas in the Sulphur burner unit and the inventory of the gas is in the pipeline from the unit to the sulphiter only.

Major hazard is leakage; being toxic it can lead to serious injuries and health concerns. Qualitative risk analysis by using ALOHA Software is done & appended in **Appendix K.**

Following has to be included:
Mitigation Measures suggested based on QRA:

1. Before the plant start up and every six months, pressure test and thickness test of all the equipments and piping carrying Sulphur di-oxide must be carried out to avoid leakage.
2. There must be alarm system, in case, SO_2 leakage is suspected and detected by smell, to warn all workers of the leakage.
3. SO_2 leak detectors may be installed.
4. All operators must be aware of Emergency Shutdown procedure and action to be taken to warn authorities to sound alarm.
5. Emergency Shutdown procedure and action to be taken should be displayed in the SO_2 production area in the local language.
6. It should form an important part of mock drill to be carried out as per on-site emergency plan.
7. In case of leakage as envisaged in MCA of flange joint leakage, area around SO_2 production unit and part of the main plant must be vacated immediately.
8. In case of major leakage as envisaged in first case, area around 120 meters to 300 meters will be heavily affected and full onsite emergency plan for the entire plant will have to put in action and if necessary population around 1 to 1.5 km will have to be warned.

7.6.4.1 Mitigation Measures suggested and measures which are in place

1) SOP for the unit operation is available.
2) Emergency Shutdown procedure is available.
3) Operators are trained.
4) Emergency Shutdown procedure, in local language is to be displayed.

7.6.4.2 Hazard quantification

Following are the toxic properties of SO_2
NFPA rating N(H)=3, N(F)=0 and N(R)=0, TLV= 2 ppm

Toxicity Index

Toxicity Number: The toxicity number (Th) is derived from the NFPA health factor Nh. Nh is an integer number ranging from 0 to 4.

Table 7.2 Toxicity Number

Nh	0	1	2	3	4
Th	0	50	125	250	350

Penalty Factor: The Penalty Factor (Ts) is the second toxicity parameter used to determine the TI. The Ts value is derived from the 'Threshold Limit Values (TLV)'.

TLV-values are drawn up by the American Conference of Governmental Industrial Hygienists. TLV represents a Time Weighted Average (TWA) air concentration to which workers can be exposed during a normal working week of 6 days at 8 hrs per day, without ill effects. The penalty factor is determined from the table below:

Table 7.3 TLV Level

TLV	<5	5-50	>50
Penalty factor Ts	125	75	5

Toxicity Index TI= Th+Ts/100 X (1+1.75+2.4) TI= 250+125/100 (5,15) = 3.75X 5.15, which is equal to **19.3**

Resulting TI values are ranked into three categories:

1-5 Light
6-9 Moderate
10-up High

Hence Toxicity index is in HIGH range. Sulphur di oxide is produced by oxidation of molten Sulphur in situ in a standard readymade unit as described above and is used in Sulfitation of Sugar cane juice. There is no storage of Sulphur di oxide, as it is produced at the consumption rate and when required.

7.7 CO-GENERATION PLANT

Company has existing 28.3 MW Co-gen plant. Two backpressure route turbines are installed in plant. The company's present plant is standard DCS controlled and operated to take care of all safety related issues with all instrumentations, alarms and interlocks. Details of the same are provided in **Appendix L**. Similar system will be in place for expansion plant as it is standard. In addition, all the employees working in this area on the shop floor are provided with ear plugs to prevent ill effects of high noise in this area.

7.8 ON-SITE EMERGENCY PLAN

The company has an on-site emergency plan for the existing facilities. The same can be modified with inclusion of Mitigation measures and quantitative Risk analysis results given above for Sugar manufacturing section, co-generation plant and other suggestions. Please refer Appendix M– for guidelines of onsite emergency plan.

Safety Measures during regular and shut-down

It must be remembered that shutdown plant are also and sometimes more prone to accidents. Hence it is suggested that all workers, regular and contract workers should be issued proper PPE, like helmet, safety shoes etc. as necessary. All work, hot work, working at height etc. during working and shutdown period should be carried out with proper work permit and under proper supervision.

7.9 OCCUPATIONAL HEALTH ASPECTS AND MEDICAL PROVISION IN THE FACTORY

7.9.1 Medical check-up

Pre & post medical check-ups will be done of all the employees. Employees will be regularly examined and the medical records will be maintained for each employee. Pulmonary function test and periodical medical checkup shall be done once in every year. For existing sugar factory & Co-gen plant medical checkup of the employees are carried out; refer **Appendix- N** for latest health check up report.

The following tests will be conducted for each worker:

- Pulmonary Function Test
- Audiometric Test
- Vision test
- General clinical examination with emphasis on respiratory system
- Pre employment examinations
- Periodical medical examinations at the time of employment and after completion of employment.

7.9.2 Occupational Health Center (OHC)

The company has OHC center for the existing sugar plant. The facilities of the present OHC and the periodic tests to be carried out will be modified for expansion activity workers and officers in view of the above details and in consultation with the registered medical practitioner. Location of OHC with dimensions is clearly shown in the factory layout drawing; refer **Appendix - B** for the same. It will be ensured that the exiting OHC and other medical facilities at the site as per the factories act, and number of employees. Same will be augmented under expansion of sugar factory. Company will have OHC and other medical facilities at the site as per the factories act, and number of employees. Some guide lines are given below: Under rule 73 W All factories carrying out hazardous processes must have OHC with services and facilities

A) For factories employing up to 50 workers:
   i. Medical officer on retainer ship basis,
   ii. Minimum 5 workers trained in first aid, at least one shall be available during all working hours.
   iii. Fully equipped first aid box (What it should contain is also specified later)

B) For factories employee 51 to 200 workers
   i. OHC with min. floor space of 15 sq. meters
   ii. Part time medical officer
   iii. One qualified and trained dresser-cum- compounder throughout all working hours.
   iv. Equipped first aid box

C) For factories employing more than 200 workers,
   i. Full time medical officer up to 500 workers, and one more full time medical officer for every additional 1000 workers or part thereof
   ii. OHC with 2 rooms
   iii. One compounder and one ward boy 24 by 7
   iv. OHC to be equipped all emergencies

With what facilities OHC should be equipped with is given in details in schedule. Requirement of Ambulance van for any factory carrying on hazardous process shall be provided and maintained is defined under 73-X. For factories with less than 200 workers, management must have an arrangement for getting ambulance van at short notice it also details out what facilities ambulance Van should have Other important requirements are: company must have, MSDS for all hazardous chemicals at site, Pre-employment medical checkup and six monthly medical check-up for all employees, including contract workers. And record must be available. Since the operation involve storage and handling of toxic chemicals, affecting liver, kidneys, lounges, medical test must include the specific teats to check functioning of these vital organs. The company carries out medical checkup for workers as per the requirement; the health check up parameters can be modified in consultation with the qualified medical doctor.

Standard Medical facilities as required by Factory rule are expected to have been provided in the OHC for the existing plant, some important are illustrated below:

1. Well equipped First Aid Boxes will be provided in each Section of the factory.
2. Snake bite Lancet
3. In case of need, factory will be having dispensary to give effective medical facility to workers. In dispensary, sufficient stock of medicines will be available to provide to workers in case of any major emergent situation.
4. A vehicle will be always available to shift the sick/injured person to District Hospital.
5. Ambulance will be made available 24X7 in the factory to deal and take the injured workers to the district hospital.

7.10 EHS POLICY

Company will prepare defined EHS policy and would be displayed as per the norms before the expansion.

Jawahar Shetakari SSK Ltd., Hupari, Tal. Hatkanangale, Dist. Kolhapur

Condition 1

Sr. No.	Name Of Chemical	Site Data	Chemical Data	Atmospheric Data	Source Of Chemical	Source Strength	Threat Zone
1.	SULFUR DIOXIDE	• Location: JAWAHAR, INDIA • Building Air Exchanges Per Hour: .74 (user specified) • Time: June 11, 2019 1621 hours ST (using computer's clock)	• Molecular Weight: 64.06 g/mol • AEGL-1 (60 min): 0.2 ppm AEGL-2 (60 min): 0.75 ppm AEGL-3 (60 min): 30 ppm • IDLH: 100 ppm • Ambient Boiling Point: -11.5° C • Vapor Pressure at Ambient Temperature: greater than 1 atm • Ambient Saturation Concentration: 1,000,000 ppm or 100.0%	• Wind: 3 meters/second from w at 3 meters • Ground Roughness: open country Cloud Cover: 0 tenths • Air Temperature: 35° C Stability Class: C • No Inversion Height Relative Humidity: 5%	• Non-flammable gas is escaping from pipe	• Pipe Diameter: 10 centimeters Pipe Length: 30 meters • Unbroken end of the pipe is closed off • Pipe Roughness: smooth Hole Area: 78.5 sq cm • Pipe Press: 2.5 atmospheres Pipe Temperature: 35° C • Release Duration: 1 minute • Max Average Sustained Release Rate: 15.6 grams/sec (averaged over a minute or more) • Total Amount Released: 935 grams	• Model Run: Heavy Gas • Red : 85 meters --- (30 ppm = AEGL-3 [60 min]) • Orange: 576 meters --- (0.75 ppm = AEGL-2 [60 min]) • Yellow: 1.1 kilometers --- (0.2 ppm = AEGL-1 [60 min]) • Concentration Estimates at the point: • Downwind: 0.89 kilometers Off Centerline: 0.038 kilometers • Max Concentration: • Outdoor: 0.257 ppm • Indoor: 0.00351 ppm

Figure1: Threat Zone

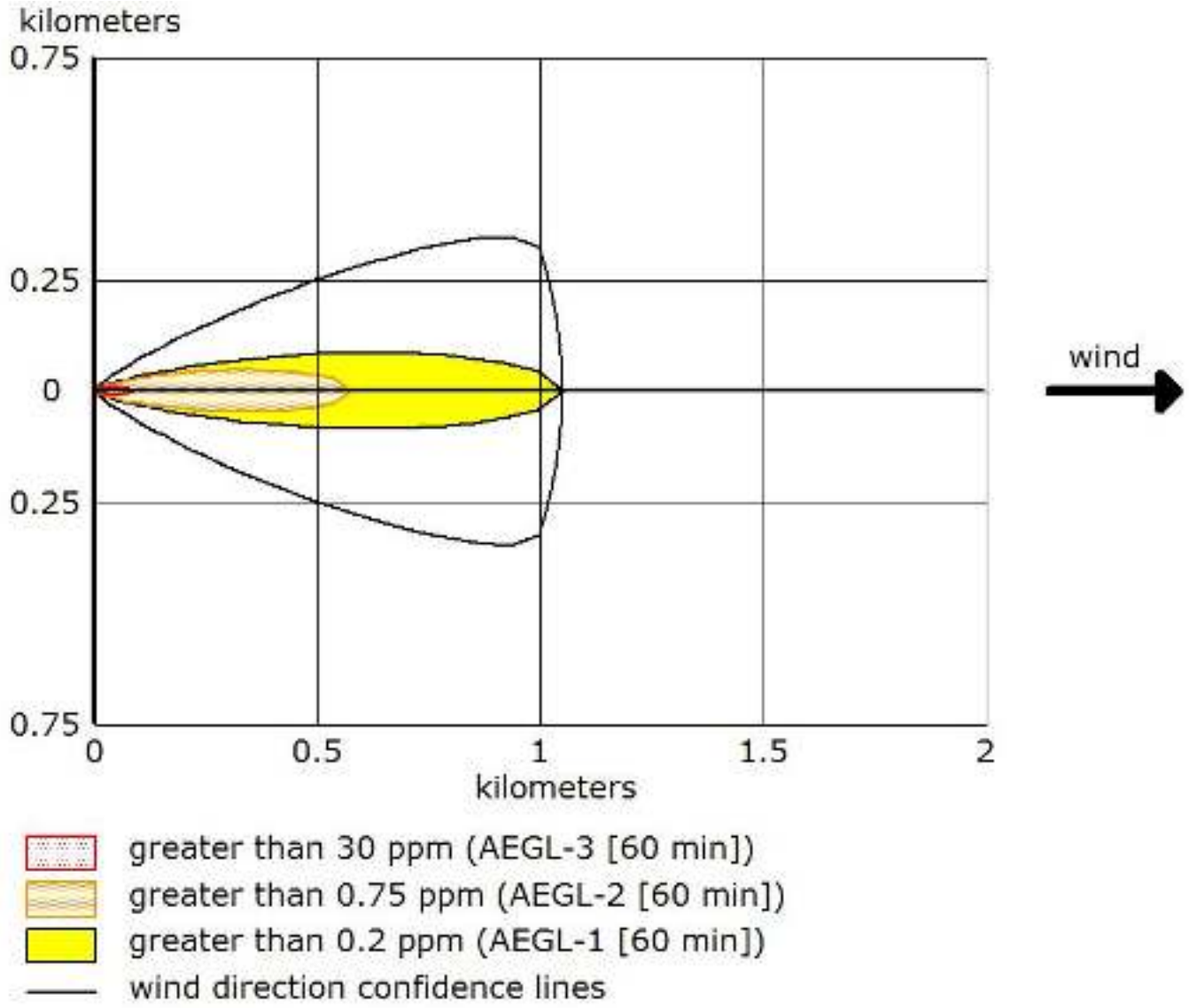


Figure 2: Threat Zone at a Point

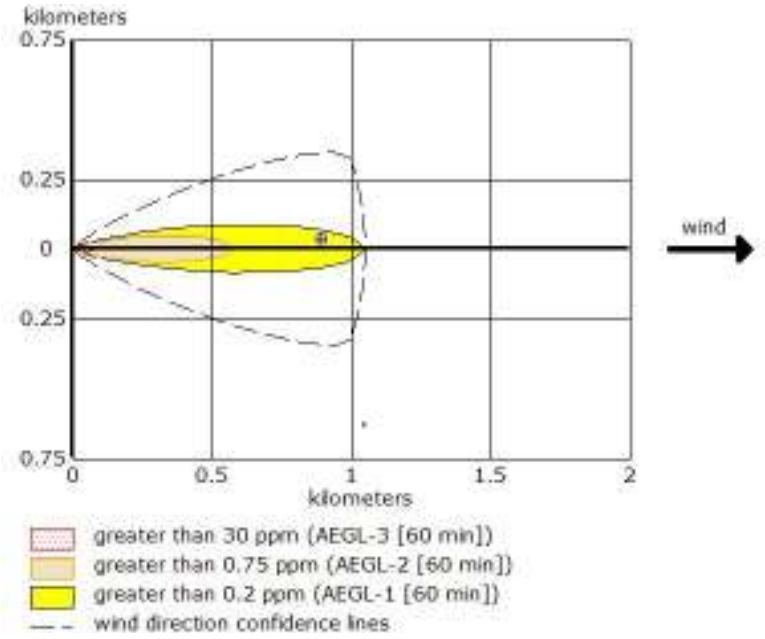


Figure 3: Source Strength at a Point

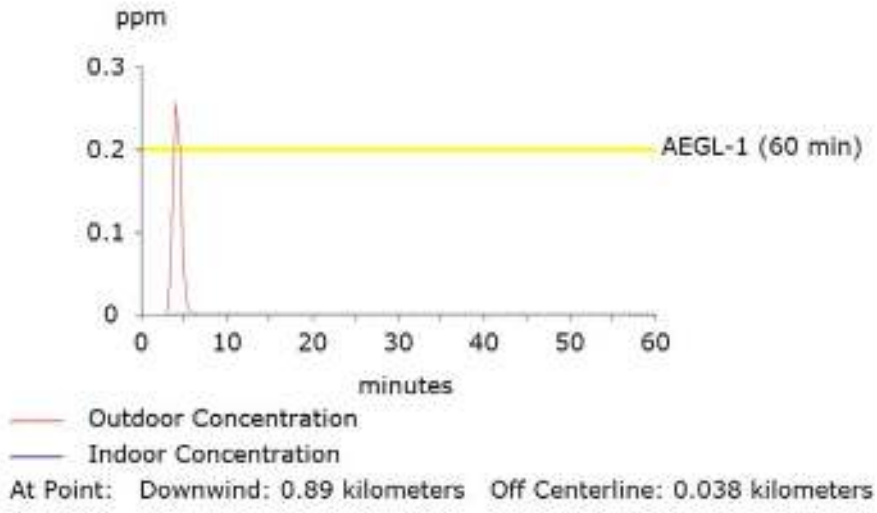


Figure 4: Source Strength

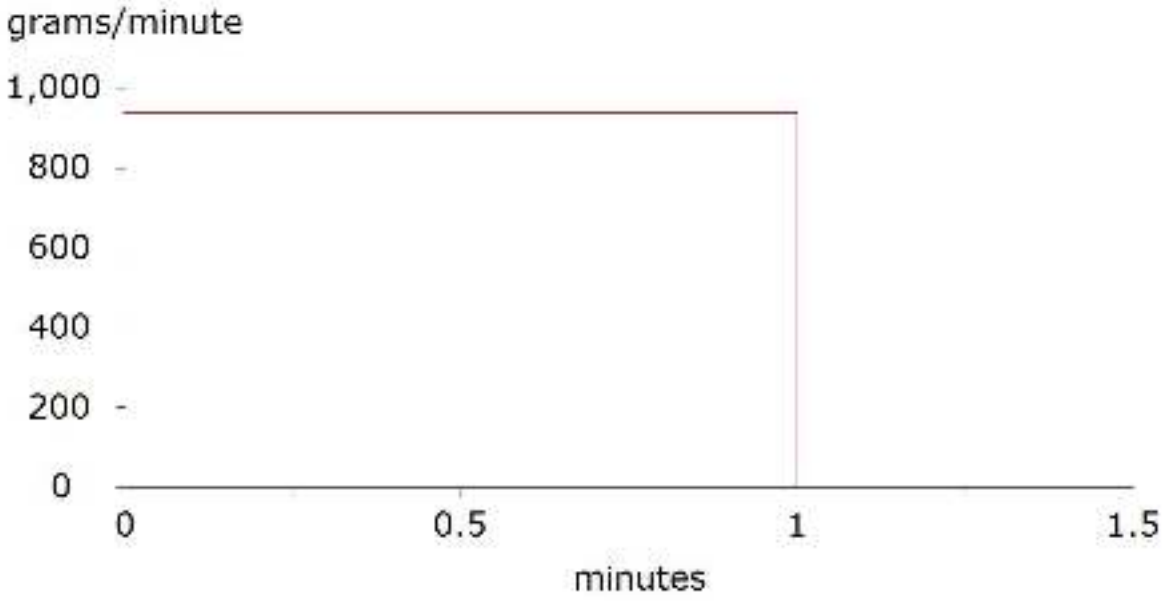
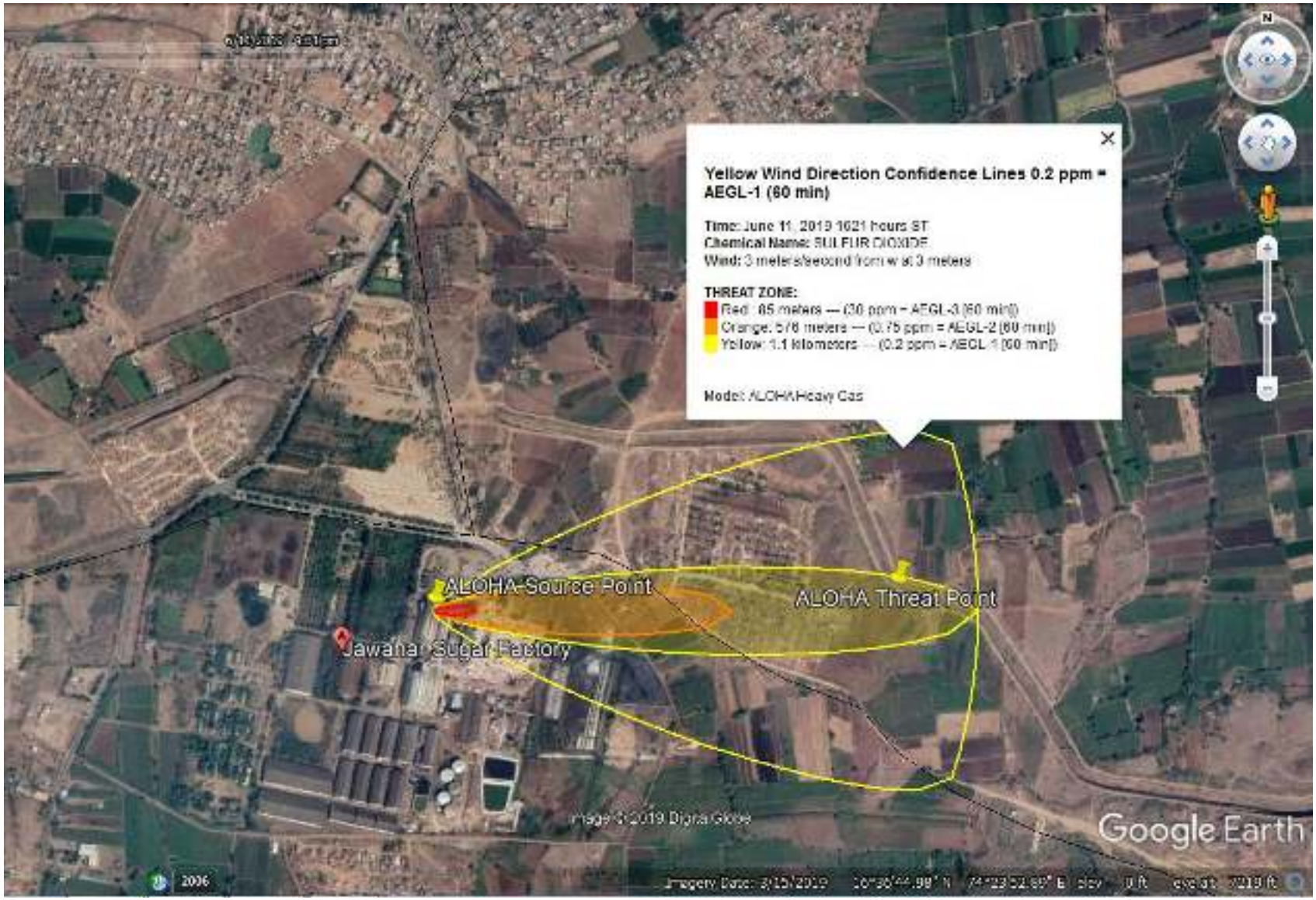


Figure 5: Google Image



Condition 2

Sr. No.	Name Of Chemical	Site Data	Chemical Data	Atmospheric Data	Source Of Chemical	Source Strength	Threat Zone
1.	SULFUR DIOXIDE	• Location: JAWAHAR, INDIA • Building Air Exchanges Per Hour: .74 (user specified) • Time: June 11, 2019 1621 hours ST (using computer's clock)	• Molecular Weight: 64.06 g/mol • AEGL-1 (60 min): 0.2 ppm AEGL-2 (60 min): 0.75 ppm AEGL-3 (60 min): 30 ppm • IDLH: 100 ppm • Ambient Boiling Point: -11.5° C • Vapor Pressure at Ambient Temperature: greater than 1 atm • Ambient Saturation Concentration: 1,000,000 ppm or 100.0%	• Wind: 3 meters/second from w at 3 meters • Ground Roughness: open country Cloud Cover: 0 tenths • Air Temperature: 35° C Stability Class: C • No Inversion Height Relative Humidity: 5%	• Non-flammable gas is escaping from pipe	• Pipe Diameter: 15 centimeters Pipe Length: 30 meters • Unbroken end of the pipe is closed off • Pipe Roughness: smooth Hole Area: 78.5 sq cm • Pipe Press: 2.5 atmospheres Pipe Temperature: 35° C • Release Duration: 1 minute • Max Average Sustained Release Rate: 35 grams/sec • (averaged over a minute or more) • Total Amount Released: 2.10 kilograms	• Model Run: Heavy Gas • Red : 130 meters --- (30 ppm = AEGL-3 [60 min]) • Orange: 843 meters --- (0.75 ppm = AEGL-2 [60 min]) • Yellow: 1.4 kilometers --- (0.2 ppm = AEGL-1 [60 min]) • Concentration Estimates at the point: • Downwind: 1.18 kilometers Off Centerline: 0.062 kilometers • Max Concentration: • Outdoor: 0.277 ppm • Indoor: 0.00427 ppm

Figure 6: Threat Zone

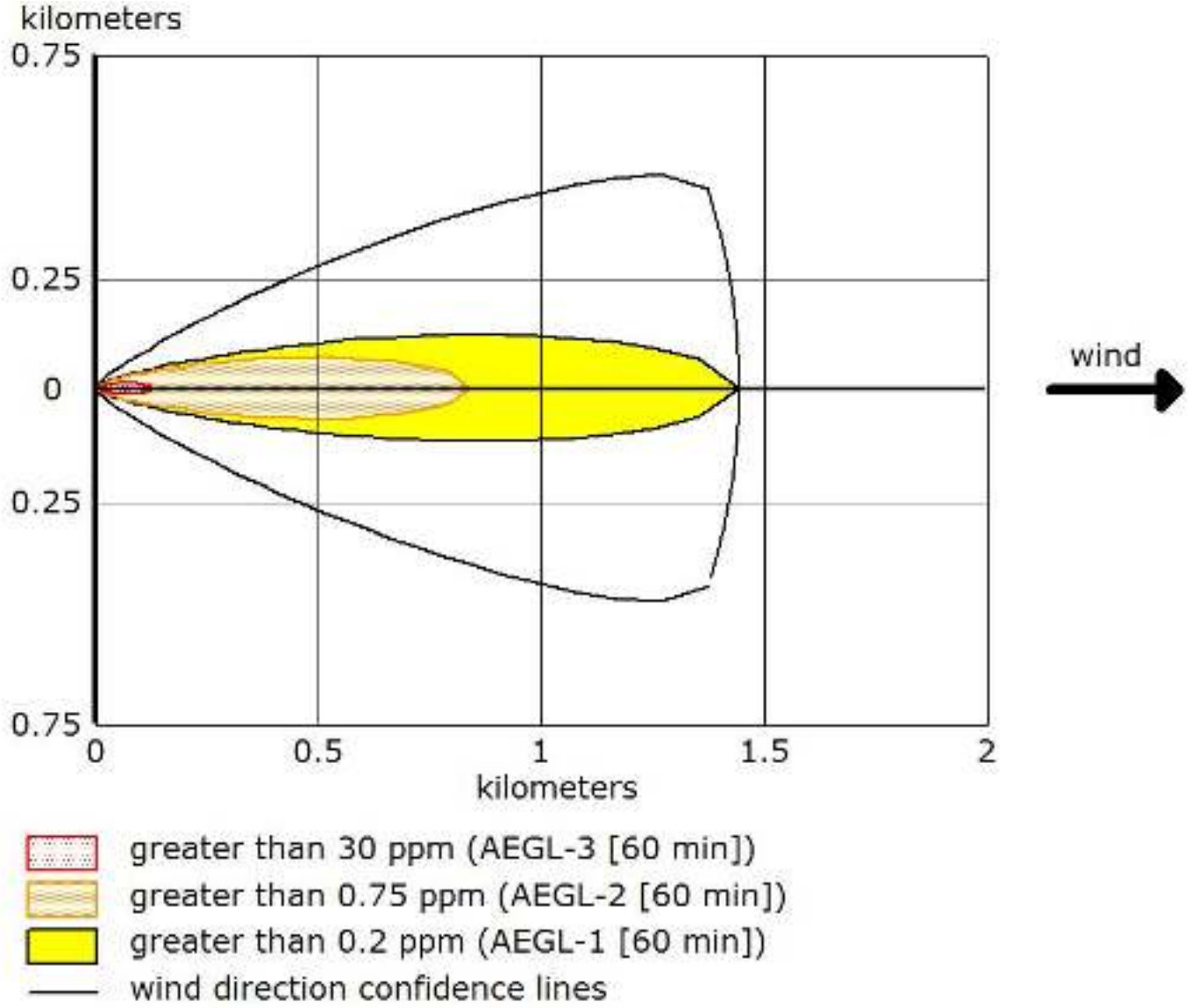


Figure 7: Threat Zone at a Point

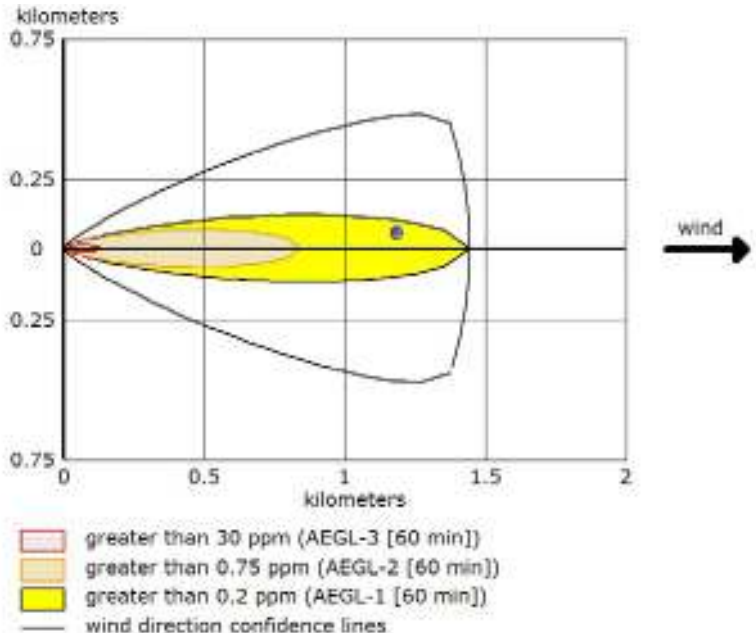


Figure 8: Source Strength at a Point

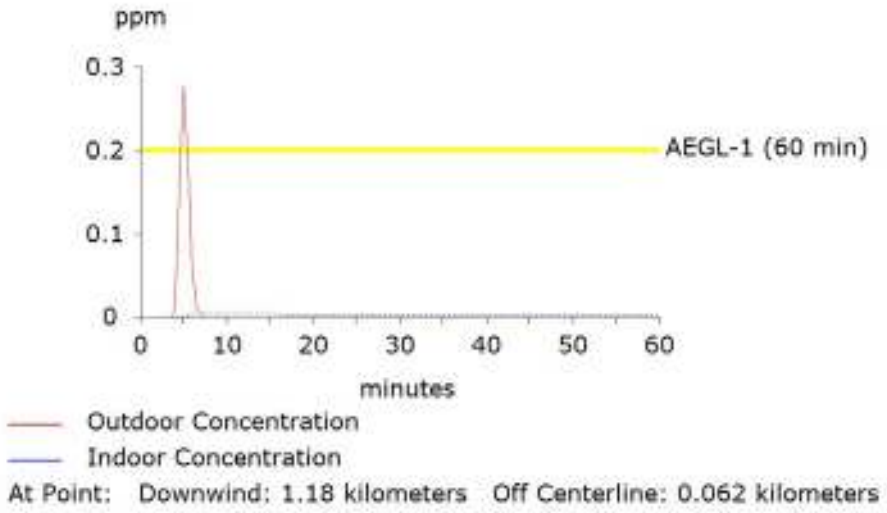


Figure 9: Source Strength

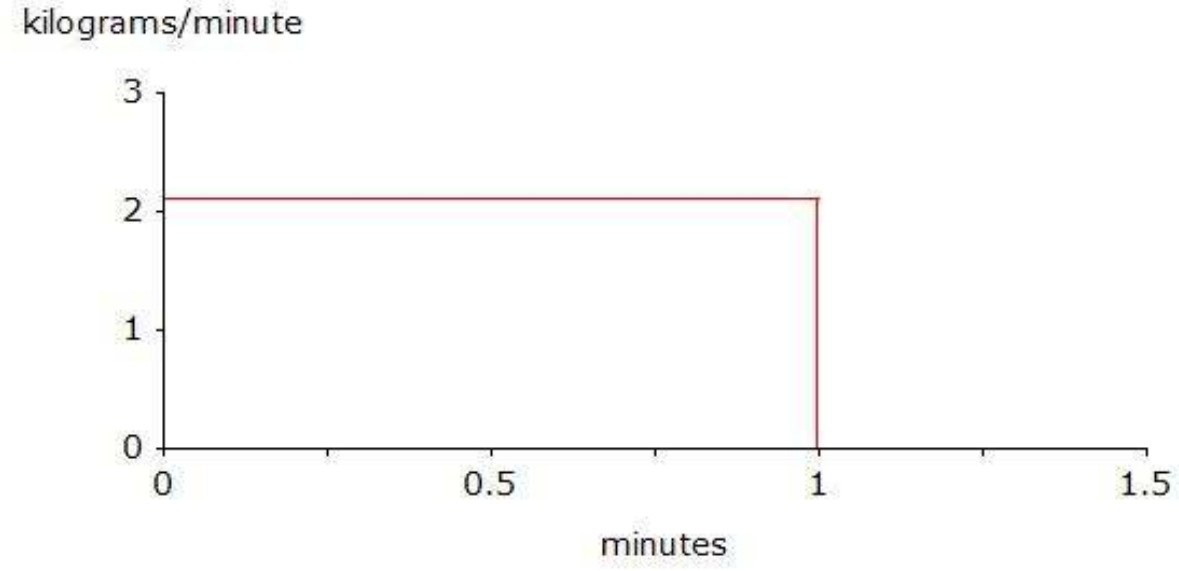


Figure 10: Google Image