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MULTIPLE SOURCE DISPERSION MODELS FOR PLANNING PURPOSES IN INDIA

PROJECT PLAN

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ESTABLISHING OF MULTIPLE SOURCE DISPERSION MODELS IN INDIA

PROJECT PLAN

1 INTRODUCTION

The Norwegian Institute for Air Research (NILU) was asked by the Norwegian Agency for Development Co-operation (NORAD) to carry out a planning mission to assess the needs and capacities for establishing multiple source dispersion models in India. The following plan is based upon the travel report from the visit in India presented in Appendix A. The scope of work is according to the work agreed upon between NORAD, Central Pollution Control Board (CPCB) and NILU in a summary meeting at NORAD.

2 SCOPE OF WORK

The scope of work for this project is to establish and apply models for long term average dispersion calculations in India (see Appendix B). The project aims at training Indian scientists on modelling and application of air quality (A.Q.) models in areas of high air pollution impact. The application of A.Q. models will be aimed at understanding the relationship between emissions, meteorology and concentrations in the area. The final goal is to establish an effective tool for future planning with respect to improvement of the air quality in different areas, and as a tool for environmental impact assessment.

3 PROJECT PLAN

The project plan for establishing the multiple source model system in India consists of several phases to be carried out by NILU in co-operation with CPCB and personnel from the State Pollution Control Board (SPCB):

1. Implementation of model system in Delhi (CPCB)
    a) collect historical data
    b) evaluation of historical data
    c) collect new data base (monitoring programme)
    d) emission inventory
    e) preparation and establishment of model system.

2. Training
    a) use of model at CPCB
    b) training of CPCB and SPCB personnel
    c) theoretical framwork (lectures)
    d) presentation of training manual.

3. Application of models
    a) Delhi, complete data base
    b) other selected areas.

4. Visit and application in different areas.

5. Follow up, improvements.

The model system will first be established on the CPCB computer in Delhi. This tool will then be applied also for training purposes. The model system will later be adapted to other regional areas decided by CPCB.

The first phase of the project will be to collect historical data of meteorology and air quality. A statistical evaluation of these data will give important information of the time and spatial distribution of pollutants. A statistical treatment of joint air quality and meteorology might in addition be a quality control of the measurement data.

Based upon the evaluation of historical data, an improved data base must be collected, including simultaneous data of air quality and meteorology. This data base will represent important input to the model calculations. Based upon our survey of potential air quality data we propose that this first complete data base for India will be collected in Delhi. The main agreement for this descission is based upon a judgement of the quality of air pollution and meteorological data, and the fact that qualified personnel will be available at CPCB in Delhi. The collecting and evaluation of historical data in Delhi will thus be carried out by CPCB.

An important task for the establishment and application of A.Q. models is the emission inventory. This work will take time and require personnel for a long period. The quality of the model calculations will strongly depend on the quality of the emission inventory for the different source categories considered; industry, traffic and domestic use of coal (cooking). The collection of emission data can start parallel to the monitoring programme.

The adaption and conversion of models to the CPCB computer will be carried out by NILU in collaboration with CPCB personnel. This work will be carried out when some information of emissions and meteorology is available. The first calculations of long term average concentrations will then be carried out for demonstration and training purpose.

The training will in addition to computational work include lectures of general meteorology and dispersion theories. Understanding of physical properties and the use of different parameters is important for evaluating input data and the results of model calculations.

After establishing the models in the CPCB computer, the emission inventory will be improved by CPCB and further model calculations will be carried out. Based upon the training of local personnel from other regions, we will prepare adapting the models to the different regional areas.

The adaptation and application of the multiple source dispersion models to other regional areas will be followed up in a later phase of the project by visits to the areas by NILU personnel.

3.1 IMPLEMENTATION PLAN FOR THE FIRST PHASE

In agreement with CPCB in Delhi, NILU has selected to first implement the modelling system at CPCB in Delhi, applying available data for this area. As a beginning of this work, the following implementation plan has been discussed and presented to CPCB and NORAD:

I. MODELLING AREA (to be presented by NILU)

1. Grid size (1 km) (20x22 km^2)
2. Co-ordinate system (see Appendix E)

II. EMISSION INVENTORY (CPCB)

1. Industrial sources
   a) point sources (h_s > 30 m) (x,y,Q,h,w,d)
   b) area sources (in each of a 440 km^2) from coal, wood and oil consumption data

2. Area sources (cooking)
   - based upon total coal consumption distributed as the population distribution assuming that coal is used by the poor classes. Population distribution given in each of ~ 60 wards of Delhi ...

3. Traffic emissions
   - from traffic density (no. cars per day) on major roads in different parts of Delhi and estimates of total no. of km driven in each km^2.

4. Emission factors (NILU/CPCB)
   a survey of representative emission factors for:
   - coal and oil burning
   - different vehicles
   - different industries

III. METEOROLOGICAL DATA

1. Wind data
   Representative wind speed and wind direction data should be collected for airports (IMD) and the CPCB station. January 1988 and 1989 was selected from first view of data.

2. Stability
   Atmospheric stability will be estimated from PG-classes for January 1988-89 (NILU).

3. Mixing heights
   Estimated from historical data (S.P. Singal, NPL). A first meteorological frequency matrix will be established for a winter month by NILU.

IV. AIR QUALITY DATA

All available air quality data for January 1988 and 1989 should be collected.

1. Continuous data
   SO_2 one hour data Jan. 1988 (89 missing?)
   NO_2 one hour data Jan. 1989 (88 missing?)

2. Integrated data (January 1988, 1989)
   SO_2 4h data and 24h data
   NO_2 4h data and 24h data
   SPM 24h data
   } monthly averages

3. NEERI data
   24h aver. SO_2, NO_2 and SPM.

4. Statistical evaluation of air quality data (NILU).

V. MONITORING PROGRAMME

For obtaining a good quality data base for simultaneous data of: emission - meteorology - air quality an intensive measurement period should be selected. We recommend January and February 1990.

The following data should be collected:

1. Air quality at all CPCB stations (SO_2, NO_2, SPM) following normal procedures (every day).

2. Continuous (1h data) for SO_2, NO_2 and CO every day at ITO, and if possible with a German mobile station in the city centre of New Delhi or around the Paharganj area northwest of Connaught Place (representative of km-scale).

3. Meteorological data

   a) Hourly meteorological data should be collected at the airports (IMD). Also radio sonde data should be made available.

   b) The quality of meteorological data at the CPCB station should be checked and hourly data collected.

   c) SODAR data should be collected by National Physical Laboratory (NPL).

   d) Possible met.data from industry should be processed.

4. Improved emission data:

   a) Traffic density data should be checked by counts at selected hours on representative main roads of Delhi.

   b) Coal consumption data and control of industry data should be undertaken.

3.2 ESTABLISHING AND USE OF A.Q. MODEL, COMPUTER PROGRAMMES AT CPCB

A multiple source Gaussian type A.Q. model for estimating long term average ground level concentrations will be developed and maid available on PC computers for the Delhi area in CPCB.

Demonstration and training for use of the model will be based upon 1988-89 data. CPCB personnel will learn to include a new good quality 1990 data base in the model.

Training in basic air quality modelling, meteorology and air pollution dispersion will be undertaken by NILU. A request from CPCB for a training manual will be met by NILU. A presentation of this training manual will be a part of a lecture programme.

Application of model and run examples will be prepared, including how to obtain input data.

Personnel requirement is:

- data experience on PC
- some programming background
- used to running programmes.

Together with the dispersion model a set of service programmes will be made available on PC computers for estimating:

- emission inventories
- scaling factors
- concentration distributions.

3.3 APPLICATION OF THE MODEL SYSTEM

3.3.1 The Delhi area

During the course of implementation and training at CPCB, the complete data base for Delhi will be available. The model system will thus enable estimates of:

a) Long term average concentration distribution of SO_2, NOx, and SPM for Delhi.

b) The relative contribution of different source categories to the total air pollution load in Delhi.

c) Single source or selected source areas (industries) impact on the air quality in Delhi.

d) Impact on the total air quality of reduction measures.

e) Representativity of monitoring stations and improvements of air quality monitoring network.

3.3.2 Other areas in India (SPCB)

The model system will be applied to other highly polluted (industrial) areas of India in a co-operation between SPCB personnel and CPCB/NILU.

An implementation plan similar to the one given in Chapter 3.1 for Delhi has to be undertaken. This work can start at the end of the next visit by NILU to India, following an introduction and a training course at CPCB.

The collection of emission data, meteorological- and air quality data in these areas can be followed up by CPCB personnel, during a period of about one year.

3.4 LAST VISIT BY NILU, FOLLOW UP OF CPCB/SPCB-WORK

After about one year of work with the A.Q. modelling system in different areas of India, NILU will visit CPCB and selected areas to support the model application in these areas.

The use of the models for specific areas, and additional training of local personnel will be undertaken. A follow up programme for this purpose will be established during the training period at CPCB.

As data will be collected for model application in different areas, this programme should be followed up by a model performance evaluation.

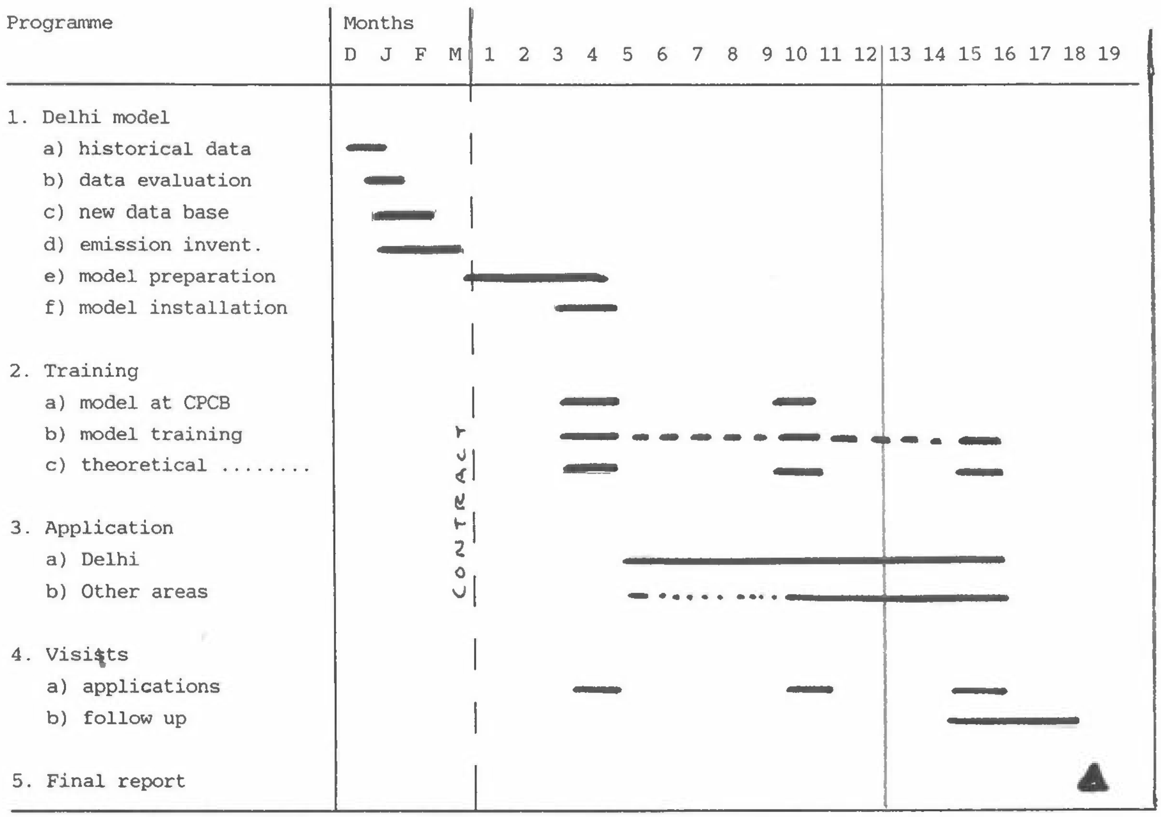
The application of other more complex type of models should be discussed based upon the model performance in the selected areas. A survey should be presented of different models. As a basis for a deversified selection of models for use in areas of specific problems. The latter work is, however, not included within the scope of this project.

4 TIME SCHEDULE

The time for starting the project will depend upon the time needed to achieve a written and signed agreement between Norway and India. The following time schedule can be indicated.

The time schedule indicates a total of three visits by NILU to India. The first is assumed to take place soon after the agreement has been signed, but not earlier than April 1990. This visit will include installation of the models, preparation of input data, the first model calculations and training of CPCB and invited SPCB personnel.

In the period between the first and second NILU visit, the CPCB personnel will finish the emission inventory for the Delhi area and carry out further model calculations for long term average concentrations. The SPCB personnel will during this period start collecting and evaluate data needed to adapt the model system to their areas. At the end



of this half year period, the CPCB personnel will support installation of the model system in the other regional areas. The first model calculations will be carried out in co-operation between CPCB and SPCB.

The second NILU visit, which according to the time schedule will take place about 9 months after "contract". NILU will follow up the modelling work carried out in Delhi and the adaptation of the model system in other areas. Between this visit and the final NILU visit, further improvements in Delhi and the regions will be carried out by CPCB and SPCB. The last NILU visit will take place approximately one year after first visit and will include a final evaluation of the use of dispersion models in India and a further training of the local SPCB personnel, if necessary. Also model performance and future further development will be discussed.

It must be pointed out that the above time schedule is tentative. The scedule might be subject to changes depending upon progress of work in the different phases given above.

5 COST ESTIMATE

The cost estimate reflects different options for the NILU visits to India;

a) 2 persons together during two separate months
b) 2 persons together one month and one person during the last two months.

The cost estimates is based upon the 1990 NILU prices.

A. Two travels

Preparation	NOK 30 000,-
Travels	NOK 60 000,-
Subsistence	NOK 132 000,-
Salary	NOK 608 000,-
Total	NOK 830 000,-

B. Three travels

Preparation	NOK 30 000,-
Travels	NOK 60 000,-
Subsistence	NOK 135 000,-
Salary	NOK 630 000,-
Total	NOK 855 000,-

APPENDIX A

Visit to India
27.11.-8.12.1989

A1 INTRODUCTION

The aim of the 10 day visit to India was to evaluate the present need for air quality modelling and surveillance of air pollution. Representatives of the Norwegian Institute for Air Research (NILU) on this planning mission were T. Bøhler and B. Sivertsen.

Visits were paid to the NORAD-office, to the Central Pollution Control Board (CPCB) in Delhi and to the State Pollution Control Board (SPCB) in Hyderabad in the state of Andhra Pradesh. Several other institutes were also visited in Delhi and in Hyderabad. Persons we met and had discussions with during these visits are presented in Appendix C.

The terms of reference for the project planning mission is given in Appendix B.

A2 VISIT AT NORAD

An introduction to the programme was given by Anders Tunold of NORAD. A brief summary of the background and contents of the NILU work was also presented by P.A. Gulden. After this meeting Tunold accompanied the NILU crew to the CPCB-office in Delhi.

A3 INTRODUCTORY VISIT TO CPCB

Dr. S.P. Chakrabarti, who later followed us through major parts of the programme, introduced us to the CPCB personnel supposed to be involved in the modelling work.

Four areas of India had originally been appointed for potential modelling purposes. These areas were all heavy industrialized:

1. Cochin in Kerala is assumed to be polluted from aluminium industry, petrochemical industry and harbour activities.

2. Talcher in Orissa has aluminium industry, fertilizers and a coal fired power plant. The area is not highly polluted at present but might represent a future development area and is thus interesting for planning purpose (use of models).

3. Vishakhafatnam (Vizag) in Andhra Pradesh is a very polluted area with a variety of industries; fertilizers, petrochemicals, cement, refineries, zink smelter, steel and iron, harbour activities and power plants.

4. Chambur near Bombay was referred to as "the gas chamber of India". The size and complexity of this area and the variety of sources seem already through the first introduction to be too complex for a first modelling exercise. This area has to be included in a later part of the development.

During the introductory discussions the Delhi area was also mentioned as an interesting city-area for modelling exercises. To include major industries and estimate emissions from traffic and area sources within a total grid area of ~ 20x30 km^2 (grid size of 1 km) should be possible. At least this could be accomplished for a first model demonstration for long term average concentration estimates. The advantage of selecting Delhi seems to be a fairly good quality data base on meteorology and air quality, and the fact that qualified personnel might be available at CPCB.

A brief presentation of the typical Indian monitoring network run by CPCB indicated a number of ~ 150 monitoring stations based upon on 24h samples for a minimum of ~ 13 days per month. The components measured are SO_2, NO_2 and SPM (Suspended particulate matter). At the India Meteorological Department (IMD) meteorological surface data and radiosonde data will be available. Data exists in statistical form only for the period 1974-77.

Emission inventories have only briefly been performed. Sources have been divided into categories as: Industry, power plants, chemicals, traffic, small scale industries and home burning for cooking purposes.

Institutions of interest to co-operate with in India might be, in addition to CPCB:

- NEERI: National Environmental Engineering Research Institute (air quality measurements)
- JNU : Jewehar Nehru University (monitoring)
- IMD : India Meteorological Department
- IIT : Indian Institute of Technology (models)
- NPL : National Physical Lab. (SODAR).

A4 VISIT AT NEERI IN DELHI

Dr. Arora gave us an introduction to the status of air quality monitoring in NEERI. This institute is monitoring air quality all over India since 1980. None of the stations are located in background areas. The philosophy has been to operate 3 stations in each city representative for industry, urban and suburban areas.

Also in Delhi NEERI is operating 3 monitoring stations. CPCB has since 1983 taken up the same type of measurements as NEERI at 6 more locations in Delhi.

The monitoring programme consists of SO_2, NO_2, TSP, dustfall and sulfation candles. The sampling time is 4 hours for periods of 24 hours for gases, and 24h-samples for SPM. Daily averages are reported. Especially the particle load is often exceeding the air quality standards of 500 $\mu g/m^3$. With an air flow rate of 1 m^3/min, the Watman filter often clogged after 2-3 hours.

Data from Delhi is reported in Atmospheric Environment (Vol. 17, no. 7, p. 1307). A large amount of the dust load seems to be a result of resuspended particles due to wind actions and traffic. Especially during summer there are high winds. During the winter season the strong inversions represent a problem.

A5 VISIT TO IMD

Dr. Sharma of IMD introduced us to the meteorological measurements related to the environmental programme at IMD. All meteorological data seem to be available for modelling purposes. At airports hourly data will be available. Parameters as wind speed, wind direction, temperature, PG-classes, precipitation, mixing heights and ventilation coefficients (Zi·U) have been stored and used.

In the Vizag area two rawin sondes are released each day (2330 and 1130 hrs.). Two surface stations are also in operation in this area.

In Talcher surface meteorological data is not readily available. One station is located in Angul ~ 3 km from Talcher. The nearest radio sonde station is Bhuhaneshwar (~ 100 km south of Talcher).

In Delhi hourly data can be available from two airports. It is, however, suggested that for long term average modelling purposes, all meteorological data are collected every 3 hours for statistical evaluation and development of joint frequency distributions of wind speed, wind direction and stability.

Data could then be processed for the Delhi airport (representative for rural areas) and for a local airport (representative for urban areas).

Radio sonde data are available on magnetic tape (EBCDIC-code). Mixing heights have been processed and presented on a monthly basis for a data set of five years (1973-77).

The tape specification is: 8 400 feet, 1/2 inch, 800 bpi, 9 track, EBCDIC, odd parity and mode NRZI.

We suggested a statistical evaluation for two months (January, July) and a total year. A statistical evaluation of the data could be performed at IMD or raw data could be transferred to CPCB for processing. The National Data Centre is located in Pune.

At the airport radiosondes were released at 00 and 12 hrs and pilot balloones at 06 and 18 hrs.

A6 CPCB CHAIRMAN

In a meeting with the chairman of CPCB dr. Paritosh Tyagi, the programme was presented, and the importance of emission data was pointed out. We briefly presented NILU and the work being performed in Norway and Europe by NILU.

Dr. Tyagi stated that the emission inventories in India was the task of CPCB. Other components than the traditional SO_2, NO_2 and TSP was of great interest to CPCB.

Asbestous fibres, hydrocarbon measurements and ozon levels were mentioned as for great interest. We also brought up the possibility of PAH measurements. The complexity of modelling photochemical and chemical reactions at this first stage of introducing models in India was discussed. It was agreed upon that these more advanced numerical models with chemical reations were not to be implemented during this project.

A7 CPCB DATA GROUP

Mrs. Gosh and Mr. Sharma introduced us to CPCBs data section. The computers available were three personal computers; PC 386 WIPRO, PC-XT and 80286. The memory and storage capacity varied between 0.6-1 Mb and 20 Mb-40 Mb respectively. The operating systems used were MS-DOS and UNIX. MS-DOS was implemented on all PCs. The data were stored in DBASE III PLUS and the programme language used was FORTRAN-77.

The NILU model system must be converted to MS-DOS and delivered on a 5 1/4" double side double density diskette for further implementation at the CPCB data section. Minimum storage available for model calculation was assumed to be about 5 Mb.

When bringing IBM compatible models on discettes to Delhi, it was suggested that back-up tapes for processing on the Informatic Centre NORD 560 computer should be available.

A8 VISIT TO HYDERABAD

A8.1 A.P. P.C.B. (ANDHRA PRADESH)

On Wednesday morning 29.11.89 at 0400 hrs. we left Delhi for Hyderabad in Andhra Pradesh. Dr. S.P. Chakrabarty accompanied us on the trip. The member secretary Y.S. Murty of the Air pollution board introduced us to the SPCB of Andhra Pradesh (APPCB) and the training centre and laboratory. The SPCB consists of 13 regional laboratories which cover different areas of environmental impact, from which most are industrial sources. A total of 12 persons are working in the laboratory.

An ultimate goal for an air quality study in this state was to apply models to the Vizag area. As a starting procedure it is interesting to first implement simple multiple source Gaussian models for long term average concentration estimates. In a later development it would be very interesting to look at photochemical reactions and accidental releases.

Green belts have been established in the surroundings of major industries. What is the actual and total impact of these green belts? (Can this problem be modelled?) Application of heavy gas modelling together with tracer studies, also in petrochemical factories, is of great interest in the area. This can be considered for future applications. It is also a possibility for financial support from the local industry.

In this study, however, multiple source Gaussian models has to be established for the area. The typical size of the area is about 10x8 km^2 with high hills in the south and in the north. The east-west oriented valley also seems to be closed to the west (see map, Appendix E).

The sources of the area are composed by:

- Ammonia factory, refineries, HDLC plant, fertilizers, cement plant, zink smelter, harbour activities, traffic and coal burning for home cooking. In addition emissions from coal fired steam trains has to be considered. Emission data can be collected in a grid specified by NILU for all point and area sources.

The requirements for meteorological data will be specified after a presentation (table) of all available data in the area. This tabulated overview will be presented by SPCB to the CPCB during one week. Air quality data seem to be available at ~ 8 stations in the area. A lot of reports are available also in the CPCB.

On the second day we met dr. K. Krishnawamy of the National Institute of Nutrition, who has been working on blood lead problems in Hyderabad. She was very interested in the similar work done by NILU. The Institute of Nutrition has been analyzing heavy metals inn foods, lead contamination in and around industries. Lead seem to be absorbed and taken up through skin rather than through inhalation.

We were also informed about the work performed by TNO in the Netherlands on a MCA-analysis (Maximum Credible Accident) for the OXO-alcohol plant located in the southwestern part of the Vizag area.

NILU presented the background for model application and demonstrated on the basis of the modelling work in Bilbao the input requirements. An introduction to the grid system and the emission inventory was given. Emission inventories have to be based upon correct and actual data on emission rates. The typical data base has to include:

- location (x-y co-ordinates)
- emission rate (kg/h)
- stack heights (m)
- stack parameters (diameter, exit gas, velocity, temperature)
- building heights within 5 x stack height for buildings taller than half the stack height.

A8.2 TRAINING CENTRE AND LABORATORY

K. Srinivasan told us that 12 persons were occupied with training and measurements within the laboratory. They were running HiVol-samples with a flow of 1-5 m^3/min, sampling particles on GF/A Whatman 8´x10´ filters. SO_2 and NO_2 was absorbed in liquids (NaOH and tetrametyl-clorid?) with an air flow rate ~1 l/min. The samples are designed as small huts similar to the Andersen sampler.

Srinivasan also demonstrated a new mobile sampler from Japan. This was a "Kimoto" handy sampler, produced by Kimoto, 3-1 Funahashi-cho, Tennoji-ko, Osaka 543, Japan. The sampler could collect particles on Gelman 37 mm filters and SO_2 and NO_2 simultaneously in bubblers. A large number of these samplers have been purchased. They have not yet been operated in field.

In the training centre we were introduced to a EPA training programme. The training centre was running education programmes on a regularly basis, with teachers brought in from different universities.

A8.3 VISIT TO NEERI IN HYDERABAD

The NEERI laboratorium in Hyderabad also was responsible for three monitoring stations in each of 10 major cities of Andhra Pradesh (industrial, commercial and rural). Also in the Vizag area 3 stations were operated. Plans for adding two more were indicated. NEERI was also planning PAH-measurements in the state.

We were shown the laboratories for water and air quality analysis. Twelve persons were employed in the laboratory, and an additional 12 persons were operating the field measurements.

A9 SEMINAR ON AIR QUALITY MODELLING

On 1 Dec. 1989 at 1000 hrs. Sivertsen gave a 2 hr. seminar on "Introduction to Air Quality Modelling" for personnel interested at CPCB. About 16 persons participated.

From an introduction of the contents of a typical surveillance programme (emissions - air quality/meteorology - modelling) the main emphasis was put on the input parameters. The different type of models were briefly discussed and the importance of a good quality meteorological data base was emphazised. A presentation of wind and stability, physical processes and measurement programmes was followed by examples given based upon an evaluation and modelling exercise performed by NILU for the Bilbao area of Northern Spain. In a summary of an operative multiple source model for planning purposes the emission data, meteorological and air quality data was again presented in the framework of model sub-routines.

In the following discussions a frequency of about 45-50% stable conditions was indicated for the Delhi area for the winter season. This seems to be a reasonable estimate.

Dr. G. Werner, who was at a 3 year contract from the Deutsche gesellschaft für Technische Zusammenarbeid GmbH (GTZ), pointed out that most decisions must be purely political, like the international agreement on sulfur reductions in Europe.

A10 VISIT TO NATIONAL PHYSICAL LABORATORY (NPL)

After a short introduction to the purpose of the NILU visit in Delhi, dr. S.P. Singal gave an interesting historical background of SODAR-measurements in India. At NPL Sodar data have been reported from the period 1977-82. Only monostatic Sodars have been used in Delhi, while the French Dopler Sodar has been installed in the Bombay area. Some of the universities have also tried to collect Sodar data.

Most of the data are available as echo signals. NPL has also used and want to use the monostatic sodar data for air pollution purposes. The typical range is usually up to 700 m, while daytime mixing height often exceeds 1 000 m. No data are available in digital form. Only one Sodar system is operating in Delhi at present.

Dr. Singal has been reporting his data frequently in the international literature (Atm. Env., 14, (2) p. 221 (1985), J. of Scientific & Industrial Res., 47, p. 520 (1988), Encyclopedia of Environment Control Techn. Vol. 2 ed. P.N. Cheremismoff, Gulf Publ. USA 1989). Dr. Singal is also responsible for the 5th Int. Symposium on Acoustic Remote Sensing in New Delhi 6 Feb. 1990.

In Delhi the well mixed unstable morning surface layer height has been found to increase proportional to the square root of time after sunrise ($Zi \propto t^{1/2}$).

We recommend that during a selected data collection period in Delhi the Sodar system should be a part of the measurement programme. The following information should be available:

- an estimate of mixing heights as a function of time of the day
- the annual variation of typical mixing heights
- the variation of mixing heights with wind directions and wind speeds.

A11 MONITORING STATIONS AND INDUSTRIAL AREAS

On a full day tour of Delhi we visited various industrial areas in the northern part of Delhi. A map of monitoring stations and industrial areas is shown in Appendix F. The first industrial area was located in E5. From the roof of a flour factory we had a perfect overview of the area. Several small stacks were seen with black smoke from the burning of coal. To the north ~ 800 m away ($N+10^0$) was a coal fired power plant (32 MWe), several stacks was seen at a distance of ~ 3 km releasing black smoke, to the west ~ 500 m away steel mills and steel industries, also to the east steel industries and a multiple of chemical plants (detergents, chlorine, NaOH, bleeching powder and vegetable oils). A wind measuring device not in use (Fuess 90 Z type) had been in operation at 2 m above roof top level.

The air quality monitoring station at Shahazada bagh was located at the roof of a electric power switching station, 30 m away from a major road and 10 m above the surface. The area was open flat, but some open air burning was seen to the west (100 m away). The instrument was an Environtech APM 415 hivol sampler for particle sampling on Whatman 8x10´ filter with a flow of 1 m^3/min, and SO_2 and NO_2 sampling at a flow of 1 l/min. The accuracy of particle sampling (weight) was indicated at ~ 5% for a concentration of about 400 $\mu g/m^3$. SO_2 was analyzed from a tetra-chloro-mercurate absorber with 1 ml sulfuric acid + 2 ml formaldehyd + 2 ml PRA (Para Rosilin Acid) made to 25 ml with destilled water. The measurements were carried out with a transmissiometer at 560 nm. Typical SO_2 concentrations at this station were 10-20 $\mu g/m^3$ (the maximum concentration was ~ 100 $\mu g/m^3$). NO_2 concentrations (24h) ranged from 20-60 $\mu g/m^3$. 4h-averages was at maximum 200 $\mu g/m^3$.

The SPM values were typically 300 to 500 $\mu g/m^3$. The maximum 24h concentrations were ~ 2 000 $\mu g/m^3$.

A typical small steel plate factory was visited. We were briefly told about the process. Oil was used for heating the raw material, before pressing and induration.

About 600 to 700 small iron based industries using fuel oil are located in the Wazipur area (map D-E-2). A high stack was seen east in the Wazipur industrial complex (textile industry).

The old CPCB office building and laboratory was visited. Meteorological data were collected with R.M. Young sensors located about 4 m above the roof top level, 15 m above the ground. A Thies Klima wind monitor was not operated at the time.

Wind speeds and wind directions were recorded on paper strip charts. The wind speed scale of 0-60 m/s seemed to be too rough for air pollution purposes. We suggested to change the scale to 0-12 m/s. A calm frequency of ~ 50% for October 1989 also indicated the inaccuracy of low wind speed sampling. A maintenance of the sampling system should be carried out on a routine basis. The wind direction at 1345 hrs. on 4 Dec. 1989 was 300^0 at a wind speed of ~ 5 m/s.

A monostatic Sodar had been operated at this location during 1986. Typical mixing heights were evaluated during the winter season at 100-200 m.

Several advanced continuous monitors for air quality sampling were seen in this laboratory. An Andersen Sierra sampler had never been operated in Delhi due to errors at the delivery. A Micro Air Sampler and advanced analyzers for CO, NOx, NO, NO_2 and SO_2 had been delivered by Germany but had never been operated in field. Two advanced mobile complete continuous monitoring stations were shown outside the laboratory. These vans were supposed to come into operation, but had not been installed for field operation so far (one was assigned for the Delhi area).

The continuous sampling <u>station ITO</u> (I7 on map) was representative for a highly trafficated area. The sampling station was located in an open area. The continuous SO_2/NO_2 inlet was located above the road side, 12 m above the surface. The hivol-sampler for 8h values of SPM and 4h values of SO_2/NO_2 (see previous description) was located 10 m from the street, 8 m above the ground.

This station was well equipped with good quality samplers; A US produced SO_2 sampler, Thermoelectron NOx (NO-NO_2) analyzer, a Beckman CO analyzer and a calibrator from Environment S.A. Not in use at present was a Beckman SO_2 analyser and a infrared gas analyzer from Kimoto.

Typical CO concentrations ranged from 0.1 to 5 ppm (max. 20 ppm). SO_2 concentrations typically ranged from 20 to 43 $\mu g/m^3$ as 24h averages. The NO_2 concentration last night peaked at 80 $\mu g/m^3$ (1h average).

Typical maximum concentrations of NO_2 was ~ 200 $\mu g/m^3$ (24h). Hourly values in June reached 330 $\mu g/m^3$.

At this location it was clear that SO_2 seems to be a less problem in Delhi than NO_2. The major problem is, however, dust and particles in the air.

A11 CPCB, AIR QUALITY AND METEOROLOGICAL DATA

A survey of monitoring stations showed that SPM, SO_2 and NO_2 was measured at the following locations:

A. Ashok Vihar, Residential (E.3)
B. Shahzada Bagh, Industrial (E.5)
C. Nizamuddin, Commercial (K.11)
D. Siri Fort, Residential, clean area (I.14)
E. Janakpuri, Residential, commercial (A.10)
F. Shahdara, Industrial (M.3)

An additional automatic station, ITO, is located in a trafficated central urban area (J.7).

Meteorological data are collected at the CPCB station in Nukherji Nagar (G.1).

Meteorological data from the CPCB station was inspected. A summary of monthly calm frequencies and prevailing wind directions is given in Appendix G for the period Jan. 1986 to Oct. 1989. This table indicate prevailing winds from around west and west-northwest during the winter months and easterly winds during the summer season. The recorder (especially wind directions) was out of order in May 1986-Nov. 1986. After a period when data were not available; in July to Dec. 1988, the starting velocity of the wind speed sensor seem to have increased considerably.

The typical frequency of calm conditions increased from ~ 5% to 20-40%, indicating that the quality of the sensor has been reduced. We recommend that maintenance of the sensor should be undertaken as soon as possible. From the CPCB meteorological data base we selected 6 months of data to look at for statistical analysis. These periods were January and February 1986, 1988 and 1989. Further examinations and statistical analysis for modelling purposes will be performed for January 1988 and January 1989.

We suggest that a good quality meteorological data base will be collected in January-February 1990. During this period the following data should also be collected:

- hourly met. data from IMD stations
- radiosonde data
- Sodar data by NPL
- continuous air quality data by CPCB
- 4h and 24h air quality data by CPCB and NEERI
- improved emission data (traffic countings, coal consumption).

A12 INDUSTRIAL AREAS

The main industrial source areas were pointed out by CPCB. Typical industrial activity are small units with stacks of 15-20 m above the ground level. The main source areas are given in Table A1, and the sites are given on the map in Appendix F. For emission data in some of these areas, see also Appendix I.

Table A1: Description of the main industrial areas in Delhi.

Name	Co-ord.	Activity
Badli	C,-2	Textile, engineering, rolling mills
Pipal Thala	D,-1	Textile, plastic, rolling mills
Wazipur	D,2	Chemical, textile, plastic
GTKR	E,2	Various small industry
Rajakri	A,17	Stone crushes (fine dust)
Lalkoa	M,17	40 stone crushes
Along road	K,19	4 asphalt plant (dust)
	K,4	Asphalt plant
	A,15	Pottery factories
Anand Part	E,5	Steel plating, varous (2000)
Moti Nagar	B,5	2000 industries, medium, large
Kirti Nagar	C,5	400-500 small stacks (20 ...)
Along river	F,5	Chem. industry
Noraina Vidar	B,7	Medium industry, 500 each
Mayapuri	A,7	
Janakpuri	-A,10	Small industry
Badapur	M+,17+	Cement plant (1800 t/d)
Connaught	I,H,8	Hotels, service act.
Along Yamuna river	L,7	Power plant, 135 MW in construction
" " "	K,8	Power plant, 284 MW
" " "	K,8	Power plant, gas, 180 MW

A13 EMISSION INVENTORY FOR DELHI

The emission inventory for applying a multiple source Gaussian type dispersion model to the Delhi area was discussed. NILU presented a method for obtaining and installing the inventory in the model.

The emission inventory has to include:

1. Industrial sources
   a) point sources (h_s > 30 m)
   b) area sources
2. Area sources, burning
3. Traffic emissions (including trains)
4. Emission factors.

A more detailed description is given in the "Implementation plan" (chapter 3.1). The work connected to the emission data should have first priority, and we suggest that one person in CPCB will be appointed responsible for this work. During the next visit NILU will help obtaining the adequate input data and train other personnel in the emission collection and application part. All existing emission data should, however, be collected prior to the next visit.

For area sources raw data for each km^2 should be:

- consumption of coal for cooking purpose
- consumption of coal in industry
- consumption of oil in industry
- emissions from process industry of SO_2, NOx and particles
- no. of km major roads (traffic density > 5 000 cars/day)
- average no. of cars
- consumption of coal by steam locomotives within the Delhi area.

For point sources each source should be specified by:

- grid co-ordinates
- emission rate (SO_2, NOx, SPM)
- stack height
- stack parameters (d, W, T_g).

A14 NORAD/DANIDA MEETING

In meetings between NORAD, DANIDA and the consultants of project plans within the environmental field were presented. DANIDA has invited consultants to plan studies around cement factories in India. One plant in the north of Karnataka was particularly mentioned. The scope of work includes: stack monitoring, ambient air quality measurements and dispersion modelling.

The dispersion models indicated to be developed by the Danish consultants represent a supplement to the multiple source models for area planning purposes established by NORAD/NILU. These projects will together give a tool for both single source industrial air pollutants (particulate matter in particular) and for total environmental impact statements for larger areas.

A15 SUMMARY MEETING AT NORAD

Representatives from NORAD, CPCB, The Ministry of Environment and NILU summarized the two week visit and indicated the contents of a future plan.

It was agreed that:

- NILU will provide a draft report with a project proposal delivered in 10 copies at NORAD, Oslo, within 3 weeks.

- The cost estimate should reflect alternative options for use of personnel and number of visits.

- The request from CPCB for a training manual for model users should be included in the plan.

- A possible future follow-up programme and further development after this project should be indicated.

After comments from CPCB on the draft proposal the report will be finalized, a decision document will be presented to the department of environment and a country to country agreement has to be signed. This process might take several months. In the meantime CPCB will collect the remaining historical data (specified by NILU and summarized in the action plan), and start collecting a new and more complete data base from 1 January 1990. This will mainly be based upon the existing measurement programme somewhat intensified under a stricter quality control. The main purpose is to obtain simultaneous data of air quality and meteorology.

It was pointed out that status reports and follow-up routines should be frequently.

APPENDIX B

Terms of reference

TERMS OF REFERENCE
FOR

A PROJECT PLANNING MISSION TO INDIA FOR THE PROJECT "MODELLING AND SURVEILLANCE OF DISPERSION AND MOVEMENTS OF POLLUTANTS"

1. Background

Reference is made to the proposed project presented in letter from the Government of India, Ministry of Finance dated February 6 1988 and Project Sketch dated 12 May 1989.

The project orginated in Central Pollution Control Board (CPCB), which has the main responsibility for control of water and air pollution in India. This responsibility is carried out at two levels, first at national level by CPCB, and secondly by State Pollution Control Board (SPCB) for the Union Territories.

The project is a consultancy assignment for transfer of technology in the area of air quality modelling. The project aims at training Indian scientists on modelling and application of models in areas of high industrial pollution.

2. Objectives

The basic objective of the planning mission is to assess the needs and capasities of the implementing institutions, type of software to be used and to make a detailed project implementation plan.

3. Scope of Work

The work shall be carried out by an especially appointed team and shall comprise, but not necessarily be limited to the following tasks:

- Evaluate the present need of CPCB and SPCB in relation to modelling and surveillance of dispersion and movement of air pollutants.

- Examine CPCB's present monitoring and surveilling system, the use of emission inventories and modelling systems.

- Evaluate the modelling systems, the input data used, (air quality data), metereological data), the quality requirement for the data and the equipment used for data collection.

- Examine the present use of the modelling and surveillance systems.

- Examine the pollution sources in the four geographical areas that has been identified by CPCB and SPCB.

- Examine the training need.

In addition to assessing the needs and capacities of the implementing institutions the team shall also:

- Present available software modelling and surveillance systems, and requirements of input data in relation to these.

- Present possible systems for emission inventories.

- Present possible areas of application for the modelling systems.

On the basis of the above mentioned issues the team shall in cooperation with CPCB and SPCB make a detailed implementation plan.

4. Participation, mode of work

The team shall consist of Mr. Bjarne Sivertsen, Senior Scientist and Mr. Trond Bøhler, Research Scientist, both from the Norwegian Institute for Air Research.

The work shall be carried out in close cooperation with CPCB, SPCB and NORAD's Resident Representative in New Dehli.

The work shall be carried out during a 10 days mission in weeks 48 and 49, 1989.

A final report written in English with conclusions and recommendations shall be submitted to NORAD within 3 weeks after the team's return to Norway.

Gustav S. Klem

Gustav S. Klem
Head
Natural Resources Management Division

APPENDIX C

Persons we met in India

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APPENDIX D

Air quality standards

CENTRAL BOARD FOR THE PREVENTION & CONTROL OF WATER POLLUTION

.....

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December 16, 1982

NOTIFICATION

AMBIENT AIR QUALITY STANDARDS

The following air quality standards were adopted by Central Board for the Prevention and Control of Water Pollution in the 47th Meeting on November 11, 1982 in exercise of its jurisdiction under Section 16 (2) (h) of the Air (Prevention and Control of Pollution) Act, 1981. These will be applicable for the period upto December 1985, will be reviewed in June 1985 and be modified as may be felt necessary at that time.

On the basis of land use and other factors the various areas of a State may be classified into three categories by concerned State Pollution Control Boards :

(a) Industrial and mixed-use areas;

(b) Residential and rural areas;

(c) Sensitive areas;

Category (a) will become self-evident on the intensity of industrial activity in an area and is bound to have somewhat inferior quality of air compared to other categories. The category (c) will cover hill stations, tourist resorts, sanctuaries, national parks, national monuments, health-resorts, and other such area where the nation would wish to conserve its clean environment even if that implies some curbs on economic activity. All areas not specifically declared by the concerned State Pollution Control Board to be classified in category (a) or category (c) will be automatically deemed to fall in category (b).

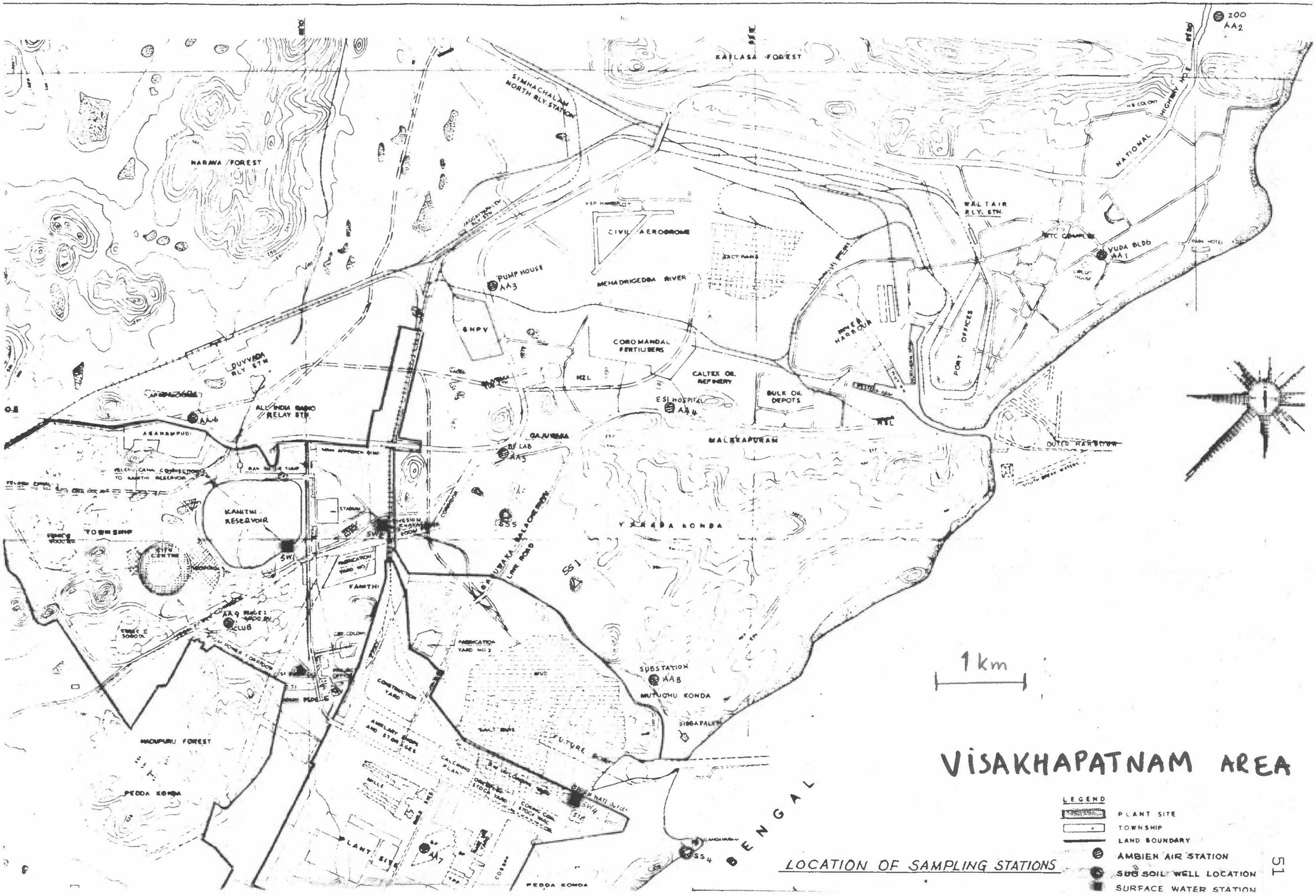
When monitored uniformly over the 12 months of an year with a frequency of not less than once a week, with a sampling time of eight hours for any sample and analysed according to procedures specified by the Central Board, the concentrations for the following pollutants shall be, 95% of the time, within the limits prescribed below :

Area	Category	Concentration microgrammes per meter cube			
		SPM	SO_2	CO	NO_x
A	Industrial and mixed-use	500	120	5000	120
B	Residential and Rural	200	80	2000	80
C	Sensitive	100	30	1000	30

Whenever and wherever three consecutive measurements spaced by atleast one-week apart, or any three out of 10 consecutive measurements spaced by atleast one-week apart are found to exceed limits specified above for the respective category, it would be considered adequate reason to institute regular weekly continuous monitoring and further investigations.

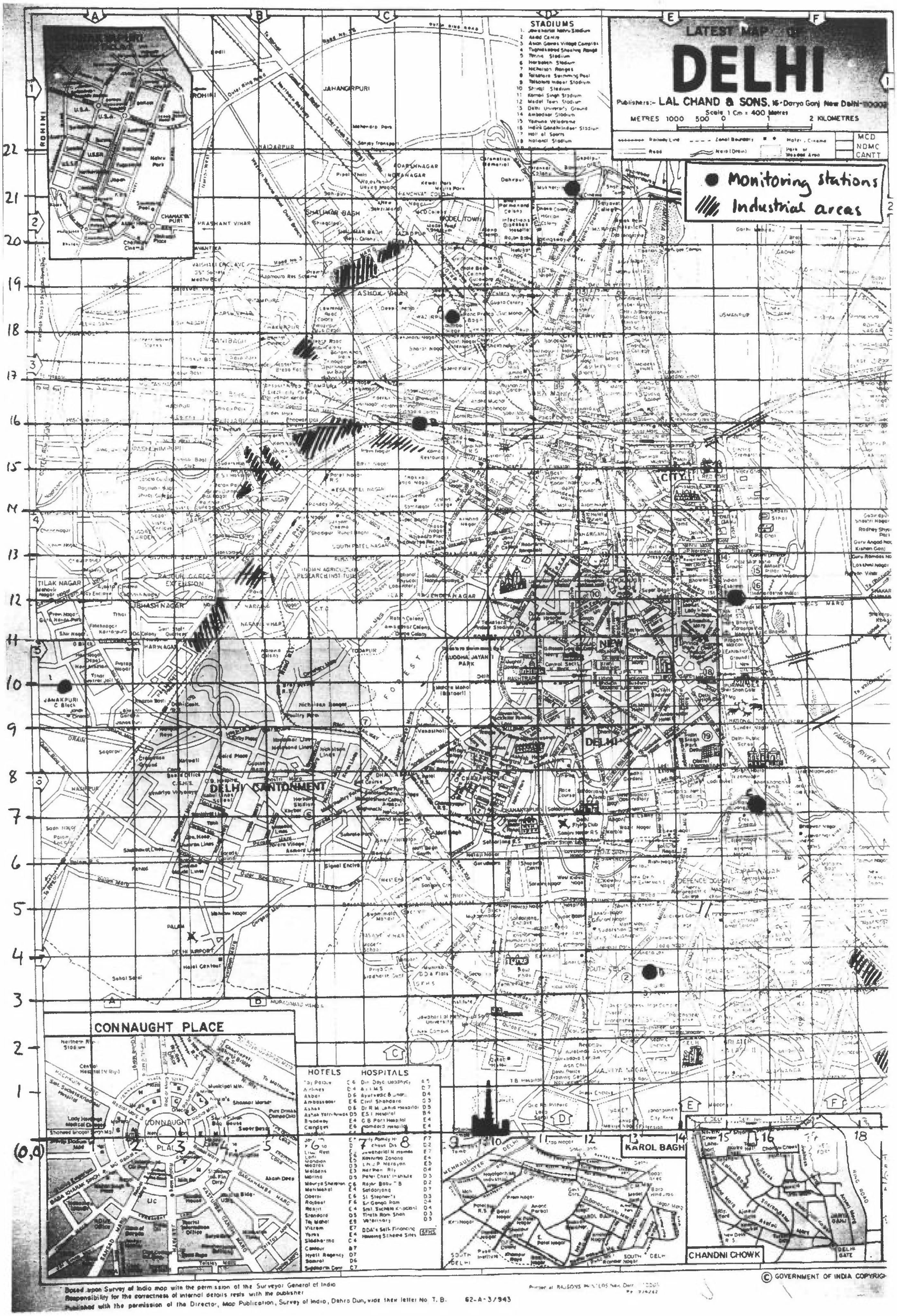
APPENDIX E

Map of the Vizag area


VISAKHAPATNAM AREA
LOCATION OF SAMPLING STATIONS
LEGEND
PLANT SITE
TOWNSHIP
LAND BOUNDARY
AMBIEN AIR STATION
SUB SOIL WELL LOCATION
SURFACE WATER STATION
1 km
ZOO AA2
KAILASA FOREST
SIMHACHALAM NORTH RLY. STATION
NATIONAL HIGHWAY NO. 5
WALTAIR RLY. STN.
YUDA BLDG AA1
PORT OFFICES
INNER HARBOUR
OUTER HARBOUR
CIVIL AERODROME
MEHADRIGEDDA RIVER
PUMP HOUSE AA3
CORO MANDAL FERTILISERS
CALTEX OIL REFINERY
BULK OIL DEPOTS
ESI HOSPITAL AA4
HZL
MALKAPURAM
GAJUWAKA
AA5
YARADA KONDA
SS5
SS1
NARAVA FOREST
DUVVADA RLY STN
ALL INDIA RADIO RELAY STN
AA6
AGANAMPUDI
KANITHI RESERVOIR
SW
TOWNSHIP
KANITHI
AA9 CLUB
SUBSTATION AA8
MUTUCHU KONDA
CONSTRUCTION YARD
FABRICATION YARD NO. 2
FUTURE
CALCINING PLANT
STOCK YARD
PLANT SITE
AA7
SW4
SS4
BENGAL
NADUPURU FOREST
PEDDA KONDA

APPENDIX F

Map of Delhi


LATEST MAP OF
DELHI
Publishers:- LAL CHAND & SONS
METRES 1000 500 0 1 2 KILOMETRES
STADIUMS
Monitoring stations
Industrial areas
JAHANGIRPURI
ROHINI
CIVIL LINES
CITY
NEW
DELHI
DELHI CANTONMENT
TILAK NAGAR
JANAKPURI C Block
DELHI AIRPORT
PALAM
CONNAUGHT PLACE
HOTELS
HOSPITALS
KAROL BAGH
CHANDNI CHOWK
YAMUNA RIVER
(0,0)

APPENDIX G

Wind data from CPCB

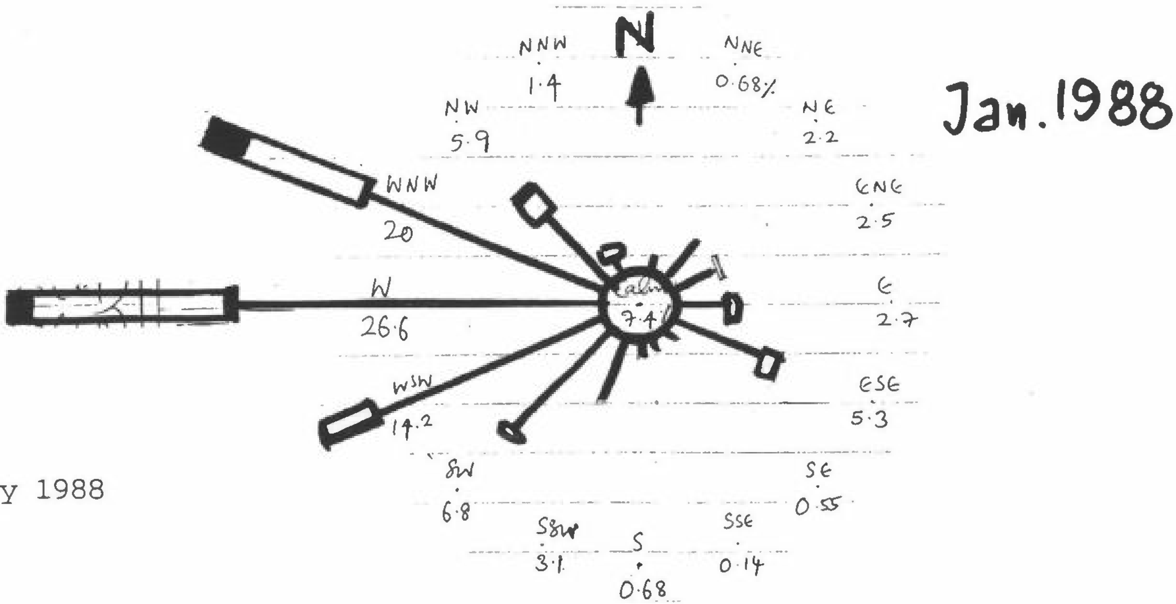
Wind data CPCB

C = frequency of calms (%)
DD = prevailing wind direction

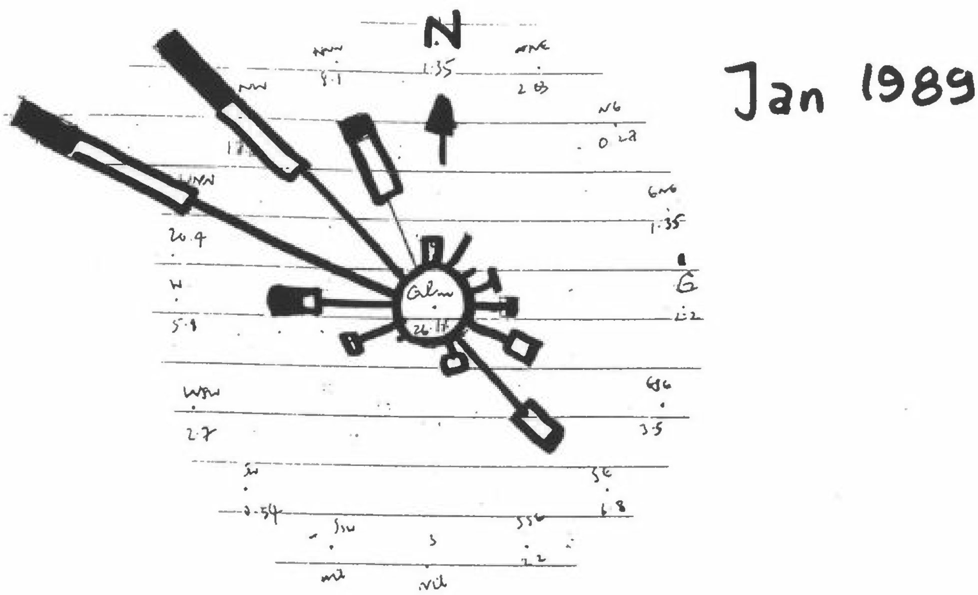
Year	Month	C	DD Prev.	%		
1986	January	4	292			
	February	10	292	20		
	March	-	-	-		
	April	-	-	-		
	May	-	68*	15		
	June	1	22*	31		
	July	2	22*	41		
	August	5	22*	19	160-180	30%
	September	2	22*	24		
	October	11	22*	32		
	November	3	22*	24		
	December	2	200±30	60		
1987	January	-	-			
	February	-	-			
	March	2	270-290	42		
	April	1	290	20		
	May	4	290	20		
	June	6	290±30	50		
	July	1	250+270	34		
	August	1	90±30	70		
	September	8	45	10	270-290	18%
	October	5	110	16		
	November	22	270+290	26		
	December	20	270	16		
1988	January	8	270	27		
	February	7	270+290	34		
	March	4	290	25		
	April	5	290	19		
	May	5	90+110	30		
	June	4	45±30	34		
	July	-	-	-		
	August	-	-	-		
	September	-	-	-		
	October	-	-	-		
	November	-	-	-		
	December	39	290+315	35		
1989	January	26	290+315	37		
	February	18	315+340	41		
	March	24	315+340	32		
	April	21	340	34		
	May	23	340	16		
	June	15	340	15		
	July	15	110	12	270	10%
	August	23	90	15	130-160	22%
	September	29	310±30	30		
	October	47	310+340	26		

* May 1986-December 1986 recorder out of order.

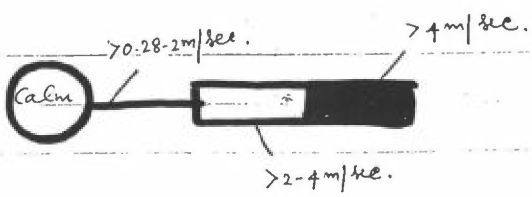
WIND ROSES



January 1988



January 1989



APPENDIX H

Air quality data for
January, February 1988/89

SO_2 data at I T O January 1988 ($\mu g/m^3$)

DATE	10188	20188	30188	40188	50188	60188	70188	80188	90188	100188
HOUR										
1	32.0	33.0	17.0	21.5	28.0	26.0	48.0	23.0	39.0	23.0
2	31.0	26.0	17.5	18.5	26.0	25.5	42.0	16.5	37.0	26.0
3	31.0	26.0	18.5	16.5	23.0	24.0	43.0	7.0	31.0	27.0
4	34.0	25.0	17.0	13.2	22.0	20.0	38.0	12.0	29.0	24.5
5	24.5	23.0	15.5	12.7	27.0	16.0	32.0	11.0	28.5	17.5
6	17.5	21.0	14.0	21.0	25.0	16.0	33.0	5.0	26.0	18.0
7	32.0	20.0	12.0	16.0	28.0	12.0	28.5	4.0	99.0	17.5
8	32.0	31.0	16.5	22.5	33.0	13.5	25.0	21.0	28.0	15.0
9	28.5	29.5	23.0	27.5	27.5	14.5	33.0	27.5	37.0	32.0
10	16.5	10.0	32.0	18.5	27.5	11.0	30.0	21.5	27.0	40.0
11	19.5	25.0	33.0	16.5	22.0	32.0	34.2	13.5	19.0	37.0
12	12.5	99.0	34.0	12.2	24.2	32.0	20.0	8.0	17.6	32.0
13	99.0	99.0	20.0	15.4	29.7	37.0	14.5	15.0	12.1	28.5
14	12.5	99.0	17.5	27.5	25.3	27.0	10.0	12.0	11.0	26.0
15	11.5	99.0	17.5	26.7	21.0	6.0	8.0	9.0	10.0	24.0
16	12.4	12.0	15.5	22.5	18.1	7.0	8.5	8.0	6.0	18.5
17	27.0	12.1	12.0	17.5	18.7	34.0	4.5	7.5	12.5	18.5
18	32.0	8.0	19.0	25.5	18.0	32.0	12.0	17.0	26.5	27.0
19	30.0	7.0	28.0	30.0	24.5	36.0	16.0	22.0	28.0	32.0
20	33.0	15.0	27.0	28.0	23.0	37.0	15.0	21.0	29.5	27.0
21	35.0	14.0	27.0	23.0	25.0	44.0	15.5	18.5	28.5	22.0
22	34.0	23.0	27.0	29.5	24.0	42.0	14.5	23.0	24.5	25.0
23	39.0	20.0	20.0	32.0	20.0	39.5	20.0	39.0	22.0	28.0
24	34.0	22.0	20.0	28.0	17.0	40.0	21.0	38.9	29.0	28.5

DATE	110188	120188	130188	140188	150188	160188	170188	180188	190188	200188
HOUR										
1	25.5	43.0	38.0	11.0	39.0	42.0	25.0	48.0	17.0	32.0
2	27.0	42.0	37.0	17.5	99.0	42.0	22.0	47.0	17.5	32.0
3	27.0	35.0	34.0	16.5	33.0	39.0	15.0	43.0	17.0	31.0
4	23.0	34.0	33.0	18.0	29.0	37.0	15.4	44.0	16.5	28.0
5	20.0	29.5	18.0	11.0	32.0	34.0	10.0	43.0	14.5	29.5
6	14.5	32.0	15.5	7.0	30.0	29.0	7.0	36.5	11.0	25.0
7	13.5	23.5	18.0	8.5	25.0	27.5	5.0	34.5	6.0	23.5
8	16.5	25.0	28.0	23.0	25.0	31.0	16.0	34.0	11.5	28.0
9	28.0	39.0	31.0	31.0	27.0	24.0	23.0	54.0	16.0	31.0
10	23.1	37.4	18.5	20.2	24.5	33.0	16.5	41.3	3.3	19.5
11	12.1	20.5	21.0	13.5	23.5	31.0	16.0	10.5	14.4	14.3
12	19.8	12.1	19.0	7.5	24.2	16.5	22.0	10.0	25.3	22.5
13	10.0	13.2	23.1	3.0	15.0	15.4	19.0	15.5	26.4	17.5
14	6.6	20.0	23.0	21.5	13.2	4.4	15.0	16.2	24.4	9.0
15	32.0	22.0	26.5	16.5	14.3	8.2	12.0	13.3	19.8	7.0
16	30.0	24.0	22.0	17.5	23.2	13.7	9.0	8.8	20.9	7.5
17	24.5	26.5	21.2	18.5	13.1	14.5	5.0	8.8	19.8	17.5
18	31.0	30.0	22.0	19.5	22.0	16.0	5.0	23.0	29.5	21.0
19	34.5	30.0	26.0	25.0	23.0	21.0	9.0	16.0	36.0	26.5
20	34.0	28.0	28.0	22.0	22.0	21.0	25.0	18.5	38.0	27.0
21	35.0	24.5	18.5	23.0	27.5	22.0	44.0	16.0	34.0	27.0
22	37.0	28.0	18.0	18.0	41.0	24.0	45.0	16.5	33.0	25.0
23	39.5	33.0	14.0	17.5	38.0	26.5	47.0	18.5	31.0	26.0
24	41.0	35.0	12.0	19.0	35.0	26.0	47.0	19.0	34.0	23.0

DAT	210188	220188	230188	240188	250188	260188	270188	280188	290188	300188	310188
HOUR											
1	14.5	19.0	99.0	37.0	13.0	41.0	39.0	34.0	25.5	31.0	26.0
2	14.5	24.0	99.0	36.0	12.0	42.0	40.0	35.0	25.0	32.5	26.5
3	17.5	22.0	99.0	35.0	12.1	38.0	39.5	34.0	24.0	31.0	26.5
4	13.0	17.5	99.0	34.0	14.2	28.0	43.0	34.0	23.0	31.0	26.0
5	10.0	14.0	99.0	33.0	12.0	25.5	42.0	30.0	15.0	33.0	25.0
6	12.0	10.0	99.0	32.0	8.0	24.9	36.5	22.0	10.0	28.5	20.0
7	6.0	10.9	99.0	26.0	17.0	25.0	34.0	21.0	6.0	21.0	20.0
8	12.0	16.0	99.0	27.0	17.5	28.0	35.0	21.0	20.0	99.0	20.0
9	33.0	28.5	99.0	42.0	27.0	33.0	24.0	32.0	25.2	27.0	28.5
10	31.5	46.0	27.0	16.5	35.5	35.5	15.5	32.5	28.5	18.5	26.0
11	26.8	38.0	22.0	7.0	17.6	32.5	10.0	30.5	23.2	20.8	25.5
12	25.3	37.0	18.5	7.0	16.5	32.0	6.0	30.0	20.5	15.5	24.0
13	15.6	43.0	18.0	10.0	21.0	31.0	9.5	30.8	19.5	10.5	23.0
14	14.5	49.0	13.5	13.0	15.5	23.0	18.2	17.5	23.5	19.5	24.0
15	11.2	37.0	13.0	6.0	12.1	23.0	7.7	16.5	20.5	26.5	21.0
16	5.5	35.0	12.0	3.2	11.0	17.5	3.0	18.0	13.5	12.2	24.5
17	21.5	38.0	7.0	17.5	16.0	21.0	16.5	24.5	10.5	5.5	24.5
18	27.0	40.0	11.0	26.0	21.0	21.0	28.0	27.0	18.5	20.0	24.0
19	25.0	29.5	24.0	35.0	27.0	26.0	32.0	29.5	23.0	24.0	22.0
20	27.0	23.0	39.0	12.0	28.0	32.0	33.0	29.0	25.5	31.0	20.0
21	22.0	99.0	41.0	15.0	51.0	37.0	34.0	27.5	23.0	33.0	19.0
22	20.0	99.0	38.5	17.5	40.0	37.0	31.0	28.0	27.0	24.0	21.0
23	12.5	99.0	38.0	21.0	42.0	36.0	34.0	31.0	26.0	27.0	21.5
24	13.5	99.0	35.0	19.0	41.0	39.0	37.0	33.0	29.0	26.0	25.0

Station : DELHI
Period : 01.01.88 - 31.01.88
Parameter: SO2
Unit : ug/m3

DIURNAL MINIMUM, MEAN AND MAXIMUM VALUES

		*)Diurnal		N u m b e r		
Date	Minimum	mean	Max	Nobs	99	Zero
010188	11.5	26.6	39.0	23	1	0
020188	7.0	20.1	33.0	20	4	0
030188	12.0	20.9	34.0	24	0	0
040188	12.2	21.8	32.0	24	0	0
050188	17.0	24.1	33.0	24	0	0
060188	6.0	26.0	44.0	24	0	0
070188	4.5	23.6	48.0	24	0	0
080188	4.0	16.7	39.0	24	0	0
090188	6.0	24.3	39.0	23	1	0
100188	15.0	25.6	40.0	24	0	0
110188	6.6	25.2	41.0	24	0	0
120188	12.1	28.6	43.0	24	0	0
130188	12.0	23.6	38.0	24	0	0
140188	3.0	16.9	31.0	24	0	0
150188	13.1	26.1	41.0	23	1	0
160188	4.4	24.9	42.0	24	0	0
170188	5.0	19.8	47.0	24	0	0
180188	8.8	26.5	54.0	24	0	0
190188	3.3	21.5	38.0	24	0	0
200188	7.0	22.9	32.0	24	0	0
210188	5.5	18.0	33.0	24	0	0
220188	10.0	28.9	49.0	20	4	0
230188	7.0	23.8	41.0	15	9	0
240188	3.2	22.0	42.0	24	0	0
250188	8.0	22.0	51.0	24	0	0
260188	17.5	30.4	42.0	24	0	0
270188	3.0	27.0	43.0	24	0	0
280188	16.5	27.8	35.0	24	0	0
290188	6.0	21.1	29.0	24	0	0
300188	5.5	23.9	33.0	23	1	0
310188	19.0	23.5	28.5	24	0	0

Mean minimum for the month: 8.8 ug/m3
Mean value for the month: 23.7 ug/m3
Stand.dev. for the month: 9.6 ug/m3
Mean maximum for the month: 39.2 ug/m3

*) Averaging time is betweeen 01 - 24

Station : DELHI
Period : 01.01.88 - 31.01.88
Parameter: SO2
Unit : ug/m3

MEAN DIURNAL VARIATION

Hour	Mean	Stand. dev.	Max	Number Nobs	Number 99	Number Zero
01	29.7	10.3	48.0	30	1	0
02	28.9	9.7	47.0	29	2	0
03	27.2	9.4	43.0	30	1	0
04	25.9	9.1	44.0	30	1	0
05	23.0	9.6	43.0	30	1	0
06	20.3	9.3	36.5	30	1	0
07	18.7	9.1	34.5	29	2	0
08	23.2	6.9	35.0	29	2	0
09	29.5	7.3	54.0	30	1	0
10	25.3	9.9	46.0	31	0	0
11	22.0	8.4	38.0	31	0	0
12	20.1	8.6	37.0	30	1	0
13	19.4	9.0	43.0	29	2	0
14	18.4	8.5	49.0	30	1	0
15	16.7	8.1	37.0	30	1	0
16	14.9	7.8	35.0	31	0	0
17	17.3	8.1	38.0	31	0	0
18	22.6	7.5	40.0	31	0	0
19	25.7	6.9	36.0	31	0	0
20	26.4	6.6	39.0	31	0	0
21	27.5	9.5	51.0	30	1	0
22	27.9	8.3	45.0	30	1	0
23	28.7	9.2	47.0	30	1	0
24	28.9	9.1	47.0	30	1	0

SULPHUR DIOXIDE (SO_2) & NITROGEN DIOXIDE (NO_2) IN DELHI

1988

JAN1988

MONTH : JANUARY
UNIT : ug/m^3

Sl. No.	Monitoring Station	Parameter	Mean (10-am-2pm) (A1)	Mean (2pm-6pm) (A2)	Mean (10pm-2am) (B1)	Mean (2am-6am) (B2)	Standard Deviation A1	Standard Deviation A2	Standard Deviation B1	Standard Deviation B2	No. of Observat A1	No. of Observat A2	No. of Observat B1
1.	Ashok Vihar	NO_2	22(21)	23(22)	25(22)	19(17)	7	7	11	9	10	8	11
2.	Shahzada Bagh	SO_2	60(49)	65(51)	79(77)	38(33)	35	40	19	19	9	9	9
		NO_2	64(56)	45(41)	27(26)	24(21)	28	19	7	11	9	9	9
3.	Siri Fort	SO_2	7(4)	1(1)	9(5)	6(2)	7	2	10	7	8	8	11
		NO_2	31(29)	29(28)	33(31)	31(30)	12	8	12	10	8	8	11
4.	Janakpuri	SO_2	11(4)	12(3)	25(13)	22(10)	14	19	22	22	8	8	9
		NO_2	27(25)	24(22)	37(31)	26(22)	10	11	23	16	8	8	9
5.	Nizamuddin	SO_2	11(7)	20(13)	22(18)	17(14)	10	16	15	10	10	11	11
		NO_2	44(38)	43(36)	42(30)	37(34)	25	15	15	18	10	11	10
6.	Shahdara	SO_2	14(12)	12(10)	17(16)	13(8)	5	7	8	7	9	10	10
		NO_2	22(18)	14(13)	16(17)	14(13)	12	4	8	6	9	10	10

Note : Number in Brackets shows Geometric mean value.

SULPHUR DIOXIDE (SO_2) & NITROGEN DIOXIDE (NO_2) IN DELHI

MONTH : FEBRUARY 1988
UNIT : $\mu g/m^3$

Monitoring Station	Parameter	Mean (10am-2pm) (A1)	Mean (2pm-6pm) (A2)	Mean (10pm-2am) (B1)	Mean (2am-6pm) (B2)	Std. Dev. A1	Std. Dev. A2	Std. Dev. B1	Std. Dev. B2	No. of Observations A1	No. of Observations A2	No. of Observations B1	No. of Observations B2
shok Vihar	SO_2	7(3)	12(3)	15(5)	15(7)	12	18	16	16	10	10	10	10
	NO_2	33(30)	35(32)	35(30)	28(27)	14	15	16	6	10	10	10	10
ahzada Bagh	SO_2	64(61)	56(53)	52(50)	55(51)	25	17	16	15	11	11	10	9
	NO_2	50(44)	38(33)	29(25)	22(21)	21	18	20	12	11	11	10	9
Irifort	SO_2	3(3)	5(3)	-	-	4	5	-	-	9	8	-	-
	NO_2	30(28)	31(28)	33(20)	38(36)	12	11	11	14	9	8	9	9
nakpuri	NO_2	19(16)	24(17)	20(19)	26(22)	11	19	8	15	10	10	11	11
	SO_2	-	-	-	-	-	-	-	-	-	-	-	-
izamuddin	SO_2	16(5)	20(7)	19(9)	9(7)	17	26	13	6	9	8	10	10
	NO_2	18(13)	17(12)	24(20)	22(15)	11	13	13	16	10	9	10	10
ahdara	SO_2	13(11)	19(14)	11(8)	7(5)	6	14	6	7	11	11	11	11
	NO_2	14(12)	19(18)	14(13)	10(9)	5	5	8	4	11	11	11	11

ote : Number in Brackets shows Geometric mean value.

SULPHUR DIOXIDE (SO_2) & NITROGEN DIOXIDE (NO_2) IN DELHI

Month : Jan. 89
Unit : $\mu g/m^3$

Monitoring Station		Mean * 10am–2pm (A1)	Mean * 2pm–6pm (A2)	Mean * 10pm–2am (B1)	Mean * 2am–6am (B2)	Standard Deviation A1	Standard Deviation A2	Standard Deviation B1	Standard Deviation B2
Ashok Vihar	SO_2	6(4)	7(4)	6(4)	5(3)	7	9	6	6
	NO_2	34(25)	34(27)	20(11)	20(13)	20	18	25	21
Shahzada Bagh	SO_2	18(14)	15(9)	20(16)	17(13)	10	8	18	11
	NO_2	21(18)	19(19)	26(24)	23(21)	8	6	10	8
Sirifort	SO_2	2(2)	4(3)	.6(1.1)	2(2)	2	6	1.1	2
	NO_2	31(28)	26(23)	22(22)	19(14)	12	13	4	12
Janakpuri	SO_2	8(6)	8(6)	9(7)	9(7)	8	6	6	8
	NO_2	22(29)	34(30)	24(19)	22(20)	11	20	13	9
Nizamuddin	SO_2	18(14)	20(19)	22(21)	17(16)	7	9	5	5
	NO_2	18(15)	21(21)	23(22)	18(17)	8	7	6	5
Shahdara	SO_2	13(11)	11(9)	12(10)	9(7)	7	10	7	5
	NO_2	30(29)	29(22)	30(27)	26(22)	22	18	17	14

* Figures in bracket shows Geometric mean value.

MONTH : FEB.89
Unit : $\mu g/m^3$

SULPHUR DIOXIDE (SO_2) & NITROGEN DIOXIDE (NO_2) CONCENTRATION IN DELHI

FEB 1989.

Sl. No.	Monitoring Station		Mean*				Standard Deviation			
			10-14	14-18	22-02	02-06	A1	A2	B1	B2
1.	Ashok Vihar	SO_2	11(5)	9(4)	4(3)	7(4)	13	13	3	10
		NO_2	21(13)	26(19)	21(15)	12(7)	16	22	16	11
2.	Janakpuri	SO_2	1.8	0.5	2.2	1.4	4	1.6	3	3
		NO_2	15(14)	13(11)	14(13)	18(12)	6	7	7	16
3.	Nizamuddin	SO_2	15(13)	16(13)	16(10)	12(9)	8	9	12	8
		NO_2	21(20)	24(23)	20(20)	18(17)	6	5	4	3
4.	Shahdara	SO_2	28(22)	27(24)	15(11)	7(5)	16	14	11	4
		NO_2	23(21)	25(24)	13(12)	14(13)	7	8	4	5

Sl. No.	Monitoring Station		Mean						Standard Deviation				
			7-11	11-15	15-18	18-21	21-02	02-07	7-11	11-15	15-18	18-21	21-02
1.	Sirifort	SO_2	2.5	1.6	0.4	0.2	2.5	1.8	1.8	1.5	0.9	0.7	3.0
		NO_2	12(11)	16(10)	14(11)	15(12)	8(8)	10(9)	5	23	10	10	3
2.	Shahzada Bagh	SO_2											
		NO_2											

* Figures in bracket shows geometric mean value.

SUSPENDED PARTICULATE MATTER IN DELHI

Month : Jan. 89
Unit : $\mu g/m^3$

Sl. No.	Monitoring Station	Mean*		Std. Dev.		No. of observations	
		10am-6pm	10pm-6am	A	B	A	B
1.	Ashok Vihar	237(222)	303(242)	83	207	11	8
2.	Shahzada Bagh	453(433)	247(218)	138	148	10	9
3.	Sirifort	234(260)	235(205)	134	131	9	8
4.	Nizamuddin	270(246)	294(271)	109	123	9	10
5.	Janakpuri	263(206)	237(179)	195	203	11	9
6.	Shahdara	284(270)	242(217)	105	134	10	10

* Figures in brackets shows Geometric Mean Value.

MONTH : FEB. '89
UNIT : $\mu g/m^3$

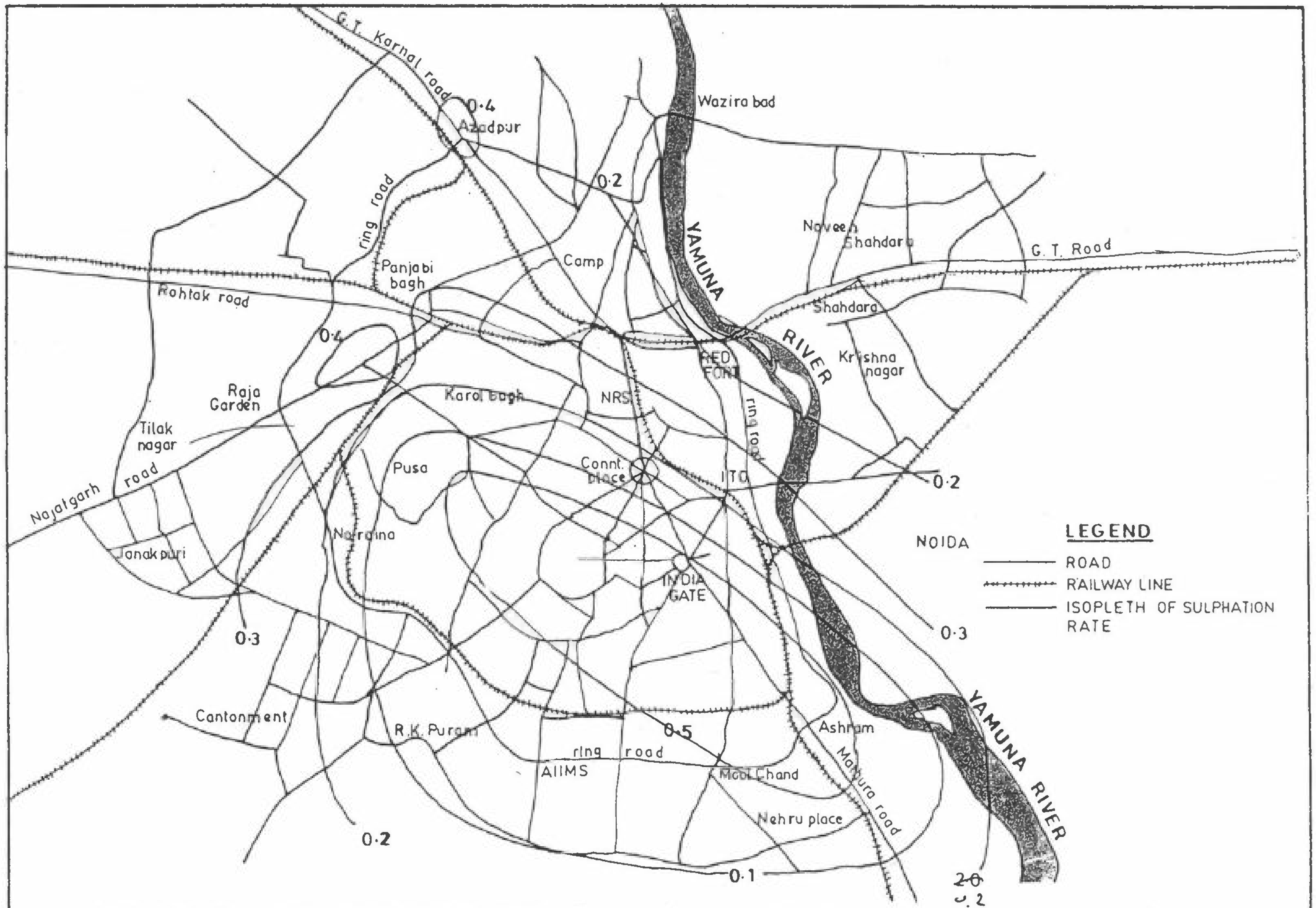
SUSPENDED PARTICULATE MATTER (SPM) IN DELHI

Sl. No.	Monitoring Station	Mean*		Standard Deviation		No. of Observations	
		10-18	22-06	A	B	A	B
1.	Ashok Vihar	441(399)	306(267)	217	143	10	9
2.	Janakpuri	252(234)	250(226)	100	117	10	10
3.	Nizamuddin	284(274)	300(261)	79	170	9	10
4.	Shahdara	229(317)	271(251)	139	109	10	9

24 hrly. Sampling of SPM

Sl. No.	Monitoring Station	Mean*			Std.Dev.			No. of Observations		
		07-15	15-21	21-7	A	B	C	A	B	C
1.	Sirifort	352 (343)	450 (423)	271 (256)	88	175	103	9	9	8
2.	Shahzada Bagh	480 (464)	561 (531)	359 (354)	128	172	140	10	8	9

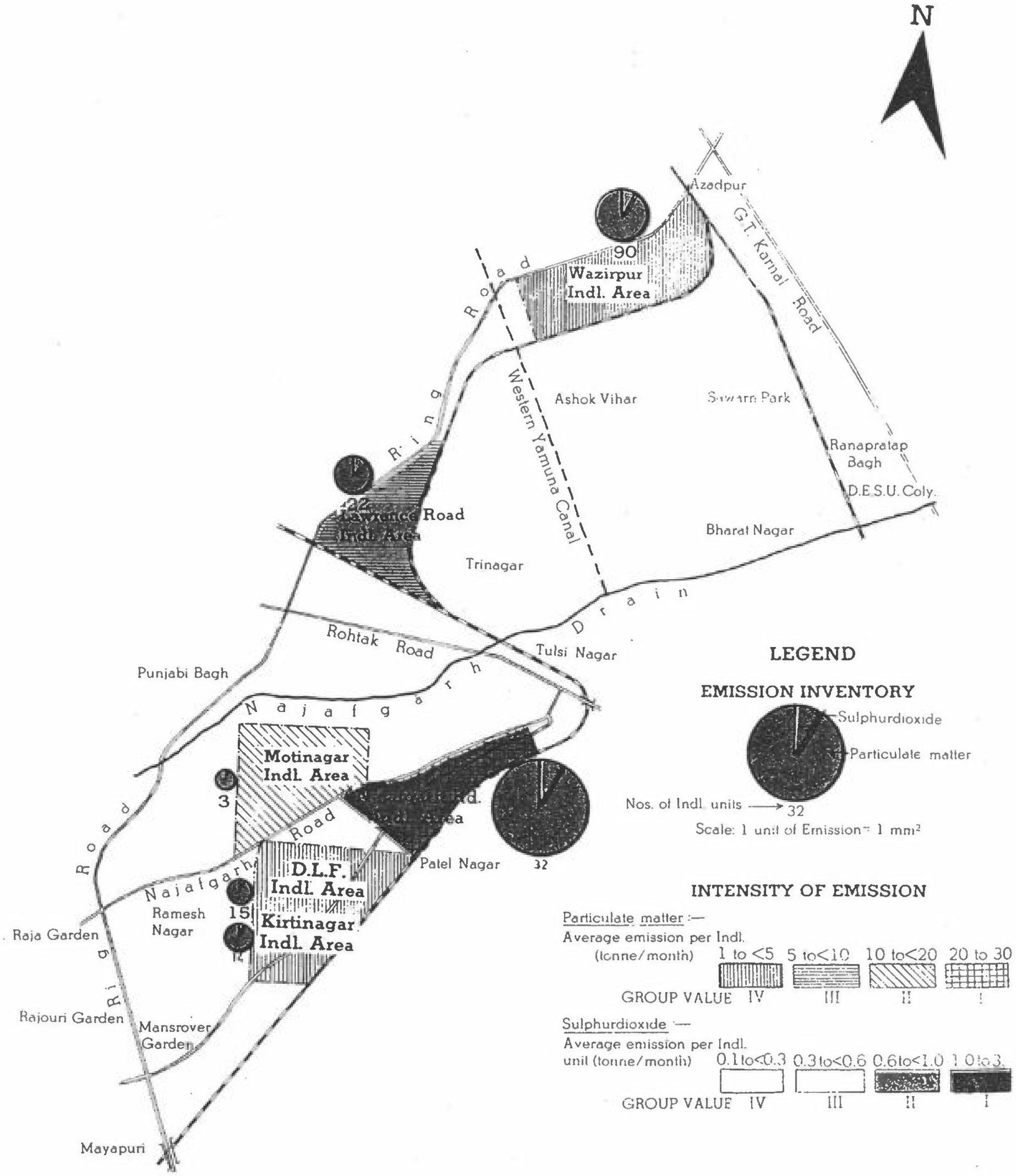
* Figures in bracket shows Geometric mean value.



ISOPLETH OF SULPHATION RATE (July 1986 – September 1986)

APPENDIX I

Various emission data for Delhi



MAP NO. 1 AIR POLLUTION CONTROL AREA-I U.T. OF DELHI (CODE: APCA/UTDLH/I)

The geographical boundary of the area is detailed as follows: Starting clockwise from the northern most point at the intersection of Ring Road and G.T. Karnal Road at Azadpur it follows G.T. Karnal Road upto Rana Pratap Bagh, then it follows Najafgarh drain till the drain intersects with Railway line coming from Rohtak. From there it follows the Ring Railway Line upto Mayapuri Ring Road Flyover. From that Southern most point the boundary moves north and north east along Ring Road upto Azadpur, the starting point. The area of the zone in about 20 sq km. The number of industrial units and the magnitude of pollutional loads are included in the *Map No. 1,* Pollutional loads being shown in piodiagram *(Vide Table 3.2 A)* and the ranking of the industrial areas by decreasing quantity of pollutional loads is shown with the aid of colour and shading *(Vide Tables 3.2 A and 3.2 B).*

TABLE-3.2 A EMISSION INVENTORY

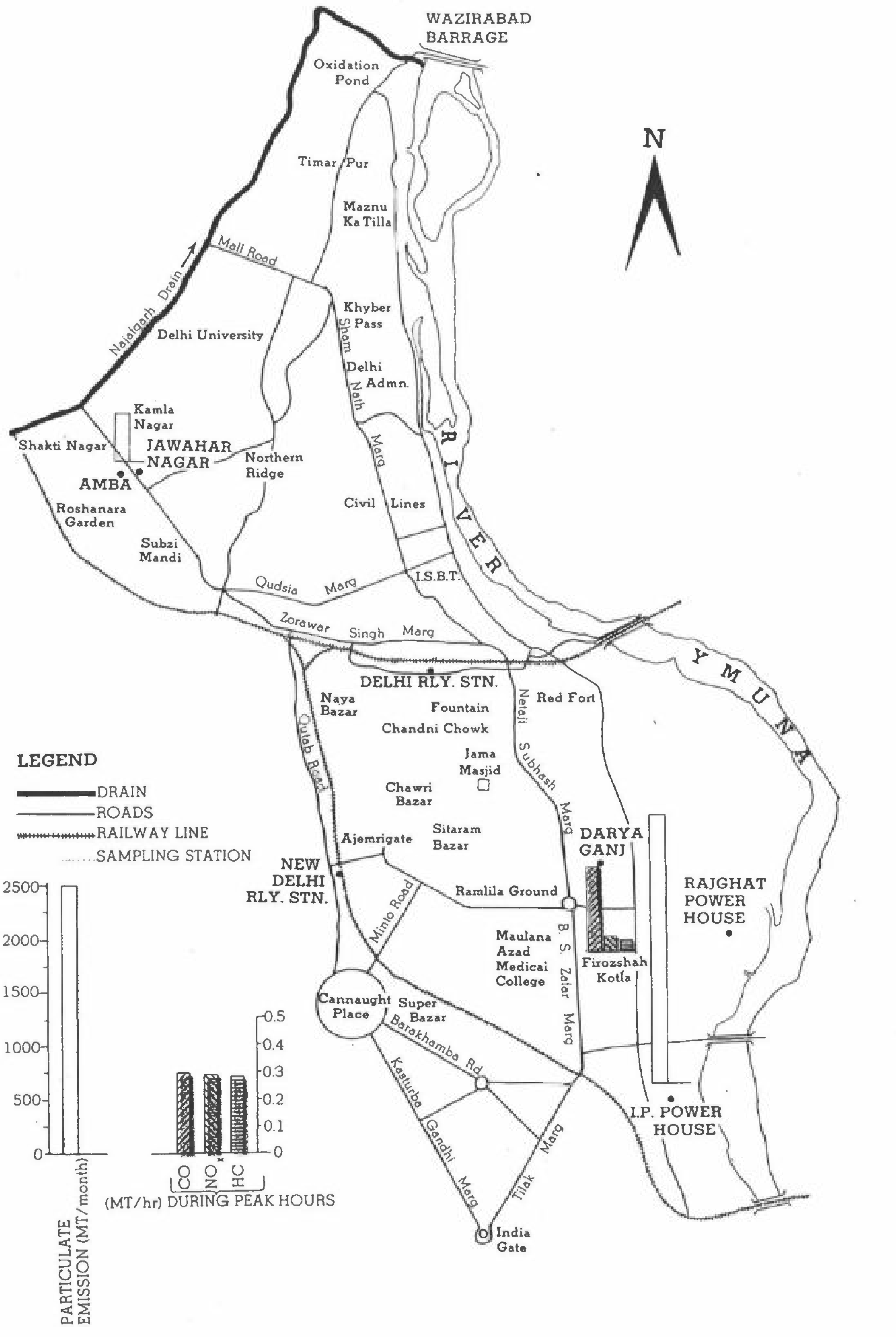
Sl. No.	Industrial Areas	No. of Industrial Units	Emission per month, tonnes			
			Sulphur-dioxide	Rank	Particulate matter	Rank
1.	Najafgarh Road	32	75.3	1	794.5	1
2.	Lawrence Road	27	20.4	2	140.2	3
3.	Wazirpur	90	18.2	3	254.1	2
4.	Kirti Nagar	14	3.0	4	66.1	4
5.	DLF	15	2.1	5	55.7	5
6.	Moti Nagar	3	1.1	6	33.4	6

TABLE-3.2 B INVENTORY OF EMISSION

Sl. No.	Industrial Areas	Average Emission per month per Industrial Unit, tonnes, per unit.			
		Sulphurdioxide	Group*	Particulate matter	Group*
1.	Najafgarh Road	2.35	I	24.8	I
2.	Lawrence Road	0.76	II	5.2	III
3.	Wazirpur	0.20	IV	2.8	IV
4.	Kirti Nagar	0.21	IV	4.7	IV
5.	DLF	0.14	IV	3.7	IV
6.	Moti Nagar	0.37	III	11.1	III

With reference to particulate emission, Group I area is an area where the range of monthly average emission per industry is 20 to 30 tonnes and the corresponding emission ranges for Group II, Group III and Group IV are 10 to $\mp$ 20 tonnes, 5 to $\mp$ 10 tonnes, and 1 to $\mp$ 5 tonnes respectively).

(*With reference to sulphurdioxide emission, Group I area is an area where monthly average emission per industry ranges from 1 to 3 tonnes and the corresponding emissioin ranges for Group II, Group III, and Group IV are 0.6 to $<$ 1.0 tonne, 0.3 to $<$ 0.6 tonne and 0.1 to $<$ 0.3 tonne respectively.



MAP NO. 2 AIR POLLUTION CONTROL AREA II U.T. OF DELHI
(Code: APCA/UTDLH/II)

b) Air Pollution Control Area II (APCA/UTDLH/II)

Based on traffic density and ambient air quality measurements for relevant parameters of carbon monoxide (CO), and oxide of nitrogen (NO_x), and hydrocarbons (HC) for vehicular traffic *(Vide Table 3.2 C)* the second area is delineated. The continuous CO recording instrument installed on Bahadur Shah Zafar Marg indicated CO level between 5,000 and 12,500 μg/cu m during 16:00 to 22:00 hours in August 1982. The indicated concentration exceeds the desired level of concentration of 5,000 μg/cu m approved as the maximum permissible ambient air quality standard for CO in industrial and mixed use areas, as mentioned in para 3.3.1.

TABLE 3.2 C Vehicular Pollution Loads at Bahadur Shah Zafar Marg

Pollutants	H.T.V.	M.T.V.	L.T.V.	Total
Carbon Monoxide (CO)	21.0	79.7	217.5	318.2
Particulates	1.2	0.64	1.79	3.63
Sulphur dioxide (SO_2)	2.4	0.68	0.44	3.51
Nitrogen Oxides (NO_x)	33.9	3.16	17.40	54.45
Hydro Carbon (HC)	3.4	3.16	32.62	39.18

H.T.V.—Heavy Tonnage Vehicle like Bus, Truck etc.
M.T.V.—Medium Tonnage Vehicle like Car, Taxi, Matador, etc.
L.T.V.—Light Tonnage Vehicle like Scooter (Two and Three-Wheeler) Motor Cycle.

All the Values are expressed as kg per hour.

Also two power stations situated in Central Delhi namely, Indraprastha Thermal Power Station and Rajghat Power Station emit sizable amounts of particulates into the air. Further the two Railway Stations, namely, Old and New Delhi Railway Stations contribute significant amounts of pollutants in ambient air by the use of coal fired steam engines in marshalling operations. In view of the above, the Central Board proposes a second Air Pollution Control Area Number Two in the Union Territory of Delhi (Coded as APCA/UTDLH/II). This area includes important historical monuments like Red Fort, Jama Masjid.

The geographical boundary of the area is detailed in ***Map No. 2*** and also described below: Starting clockwise from Wazirabad Barrage on the Yamuna River in the North it follows the Yamuna River upto Railway Bridge on the Yamuna River near Indraprastha. From that point, it follows the Railway line upto Tilak Bridge and continuous north-westwards along the Railway line upto the Tilak Marg and then encircling the India Gate, it follows the Kasturba Gandhi Marg in a north western direction upto the outer circle of Connaught Place. Along the outer circle it joins the Chelmsford Road and follows the Chelmsford Road and the Qutab Road upto where it inter-sects the Delhi-Karnal Railway line near Pul Mithai from where the boundary follows the Railway line upto its inter-sect with Najafgarh Drain near Shakti Nagar. Finally, it follows the Najafgarh Drain upto where it falls into River Yamuna near Wazirabad Barrage. The area of this zone is 35 sq km.

TABLE - 3

PETROL CONSUMPTION OF VEHICLES
(1986-87)

Sl. No.	Name of the city	Petrol Consumption, Kilolitre per year		
		IOC Data	Estimated	Correction factor
1.	Calcutta	113,083	360,379	0.31
2.	Bombay	312,916	959,220	0.33
3.	Delhi	322,917	887,34	0.36
4.	Madras	82,222	238,937	0.34
5.	Pune	76,806	110,365	0.69
6.	Hyderabad	83,194	119,224	0.697
7.	Bangalore	98,333	189,428	0.52
8.	Ahmedabad	82,083	194,789	0.42
9.	Kanpur	26,667	46,957	0.57
10.	Lucknow	23,194	45,190	0.51
11.	Jaipur	29,583	43,227	0.68
12.	Nagpur	27,778	29,897	0.93

TABLE - 4

DIESEL CONSUMPTION OF VEHICLES
(1986-87)

Sl. No.	Name of the city	Diesel Consumption, Kilolitre per year		
		IOC Data	Estimated data	Approximate fuel consumption by vehicles (in percentage)
1.	Calcutta	722,209	410,362	56.8
2.	Bombay	176,628	172,492	97.6
3.	Delhi	492,907	254,149	51.56
4.	Madras	156,744	104,452	66.6
5.	Pune	257,442	87,483	34.0
6.	Hyderabad	199,302	100,486	50.4
7.	Bangalore	199,302	65,864	33.0
8.	Ahmedabad	113,954	70,102	61.5
9.	Kanpur	124,884	60,043	48.1
10.	Lucknow	74,419	43,898	58.7
11.	Jaipur	176,047	58,320	33.0
12.	Nagpur	136.349	20,842	15.4

TABLE - 5

VEHICULAR POPULATION IN METROPOLITAN CITIES
(As on 31st March, 1987)

Sl. No.	Name of the city	Buses	Goods vehicles	Two and Three-wheelers	Four wheelers	Total
1.	Delhi	14,766	64,555	8,11,761	2,20,582	11,11,664
2.	Bombay	6,714	45,688	2,11,709	2,56,727	5,20,838
3.	Calcutta	11,376	42,791	1,37,090	1,68,661	3,59,918
4.	Madras	2,067	16,166	1,90,222	67,389	2,75,884
5.	Pune	5,704	11,366	2,47,250	59,820	3,24,140
6.	Hyderabad	17,092	16,946	2,22,139	41,862	2,98,039
7.	Bangalore	2,355	18,563	1,69,261	21,988	2,12,167
8.	Ahmedabad	1,528	16,858	2,49,833	35,453	3,03,672
9.	Kanpur*	3,615	13,390	87,030	12,387	1,16,422
10.	Lucknow	1,084	9,073	95,591	14,633	1,20,381
11.	Jaipur **	7,101	21,914	1,11,346	22,283	1,62,644
12.	Nagpur	702	7,518	80,699	9,382	98,301
		74,104	2,84,828	26,13,931	9,31,167	39,04,030

* Data pertains to January, 1987

** Data pertains to Jaipur District, 1987

Delhi 1991:
1 398 000 Vehicles
Emissions : 1319 tonnes/day
(CO: 62%).

TABLE - 6

ESTMATED VEHICULAR EMISSION LOAD IN METROPOLITAN CITIES
(AS ON 31ST MARCH, 1987)

Sl. No.	Name of the city	Vehicular Pollution Load (Tonne per day)					
		Particulates	Sulphur-dioxide	Oxides of Nitrogen	Hydrocarbons	Carbon Monoxide	Total
1.	Delhi	8.58	7.47	105.38	207.98	542.51	871.92
2.	Bombay	4.66	3.36	59.02	90.17	391.6	548.8
3.	Bangalore	2.18	1.47	21.85	65.42	162.80	253.72
4.	Calcutta	2.71	3.04	45.58	36.57	156.87	244.77
5.	Ahmedabad	2.46	2.41	33.33	56.46	149.28	243.94
6.	Pune	1.99	1.07	13.50	61.0	135.2	212.76
7.	Madras	1.95	1.68	23.51	42.05	119.35	188.54
8.	Hyderabad	1.62	1.30	14.03	46.94	105.14	169.03
9.	Jaipur	0.98	1.04	12.74	17.49	42.73	74.98
10.	Kanpur	0.88	0.90	11.14	18.53	40.35	71.80
11.	Lucknow	0.95	0.79	8.07	18.75	41.02	69.58
12.	Nagpur	0.46	0.34	4.24	13.60	29.16	47.80
	Grand Total	29.42	24.87	352.39	674.96	1916.01	2997.65

ANNEXURE I

EMISSION FACTOR USED IN ESTIMATION

Type of Boiler/ Furnace	Type of Fuel	Emission					Remarks
		Particulate Kg/Tonne	SO_2 Kg/Tonne	CO Kg/Tonne	Hydro-carbons Kg/Tonne	NOx Kg/Tonne	
Hand Fired Units	Bituminous coal	10	19 S	45	10	1.5	
Industrial/ Commercial	Fuel oil, residual	2.87	19 S	0.52	0.37	7.5	for the fuel furnace oil
Domestic	Fuel oil, Distilete	0.37	20 S	0.75	0.14	2.72	for the fuel light diesel oil
Domestic	Wood	13.7	0.5	1	1	6	-

S - Sulphur present in the fuel : Assumed value of sulphur : For coal 0.4%
Furnace Oil 4%
LDO 0.4%

CUDS/14/1984-86

TABLE 8

ESTIMATE OF AIR POLLUTION LOAD IN SHAHDARA INDUSTRIAL AREA

Area	Fuel	Fuel	Emission of pollutants (kg/month)					
	Type	Consumption Tonnes/month	Particulate	SO_2	CO	HCS	NO_x	Total
Jhilmil Tahirpur Industrial Area	Coal	422.10	4221.00	3200.00	18994.50	4221.00	633.15	31269.69
	Furnace Oil	974.00	279.54	7402.4	50.65	36.04	730.50	8499.13
	Wood	4.00	54.80	2.00	4.00	4.00	24.00	88.80
	Total	543.56	4555.34	10604.4	19049.15	4261.04	1387.65	39857.58
Friends Colony	Coal	732.00	7320.00	5563.20	32940.00	7320.00	1098.00	54241.20
	Furnace Oil	134.50	386.01	10222.00	6984.00	49.77	1008.75	11736.47
	Wood	89.50	1226.15	44.75	89.50	89.50	537.00	1986.90
	Total	956.00	8932.16	15829.95	33099.44	7459.27	2643.75	67964.57
Loni Road, Moti Ram, G.T. Road	Coal	561.00	5610.00	4263.60	25245.00	5610.00	841.50	41570.10
	Furnace Oil	626.50	1798.06	47614.00	325.78	231.81	4698.75	54668.40
	Total	1187.50	7408.06	51877.60	25570.78	5841.81	5540.25	96238.50
GRAND TOTAL		2687.06	20895.56	78311.95	77719.37	17562.18	9571.65	204060.65

TABLE 3

ESTIMATE OF AIR POLLUTION LOAD IN OKHLA INDUSTRIAL AREA

			Emission of pollutants (kg/month)					
Phase	Type	Fuel consumption tonnes/month	Particulate	SO_2	CO	HCS	NO_2	Total
Phase I	Coal	215.60	2156.00	1638.56	9702.00	2156.00	323.4	15975.96
	Furnace Oil	51.00	146.37	3876.00	26.52	18.87	382.5	4450.26
	LDO	10.00	3.70	80.00	7.50	1.40	27.2	119.80
	Wood	6.25	85.63	3.13	6.25	6.25	37.5	138.76
	Total	282.85	2391.70	5597.69	9742.27	2182.52	770.6	20684.78
Phase II	Coal	245.50	2455.00	1865.80	11047.50	2455.00	368.25	18191.55
	Furnace Oil	12.00	34.44	912.00	6.24	4.44	90.00	1047.12
	LDO	20.90	7.73	167.20	15.68	2.93	56.85	250.39
	Wood	2.50	34.25	1.50	2.50	2.50	15.00	55.50
	Total	280.90	2531.42	2946.25	11071.92	2464.87	530.10	19544.56
Phase III	Coal	4.00	40.00	30.40	180.00	40.00	6	296.40
	Furnace Oil	18.00	51.66	1368.00	9.36	6.66	135	1570.68
	Total	22.00	91.66	1398.40	189.36	46.66	141	1867.08
Grand Total		585.75	5014.78	9942.34	21003.55	4694.05	1441.7	42096.42

Table 3.4

Categorisation of Intersections Based on Traffic Density in the city of Delhi

Sl. No.	Traffic Volume* 9 am to 12.00, 4 pm to 7 pm (6 hrs)	Traffic Volume Class	Traffic Intersectiona
01	More than 30,000	I	08. DELHI GATE 05. MOOLCHAND
02	25,000 to 29,999	II	04. A.I.I.M.S 07. INDIA GATE
03	20,000 to 24,999	III	10. RED FORT 12. MOTI NAGAR 09. YAMUNA BAZAR
04	15,000 to 19,999	IV	06. ASHRAM 03. R K PURAM X'ING 02. DHAULA KUAN 01. RAJA GARDEN 11. ZAKIRA
05	Less than 15,000	V	13. AZADPUR

* Petrol-driven Venicles

Table 3.5

Traffic Density and Ambient Air Quality at Selected Traffic Intersections and at N.P.L., Nursery (September, 1984)

Sl. No.	Name of location	Traffic Volume* 9 am to 12.00, 4 pm to 7 pm (6 hrs)	Ambient Air Quality (10-hr average) µg/cu m			ng/cu m
			SO_2	NO_2	SPM	Pb
01	Delhi Gate	36,923	36	49	696	193
02	India Gate	28,414	15	20	81	90
03	Red Fort	23,871	45	80	460	166
04	Ashram	18,009	30	25	382	192
05	Azadpur	15,608	40	75	818	277
06	N.P.L., Nursery	Nil	11	15	83	46

* Petrol-driven Vehicles

Table 3.3

Traffic Volume and Ambient Air Quality at 13 Important Traffic Intersections (January and June 1984)

Sl. No.	Traffic intersections	Traffic Volume* 9 am to 12.00 / 4 pm to 7 pm (6 hrs)	Ambient Air Quality (10-hr average) µg/cu m SO_2	µg/cu m NO_2	µg/cu m SPM	ng/cu m Pb
01	Raja Garden	18,925	57	88	1,196	385
02	Dhaula Kuan	16,996	47	64	778	559
03	R. K. Puram X'ing	18,803	42	40	520	395
04	A.I.I.M.S.	29,532	51	45	450	450
05	Moolchand	33,252	65	60	460	1,802
06	Ashram	18,450	53	73	607	395
07	India Gate	27,729	28	28	282	514
08	Delhi Gate	32,240	74	85	691	571
09	Yamuna Bazar	18,773	64	76	702	390
10	Red Fort	23,135	74	92	1,112	670
11	Zakira	15,347	136	85	1,624	481
12	Moti Nagar	23,973	81	70	492	563
13	Azadpur	14,663	67	76	788	603

* Petrol-driven Vehicles

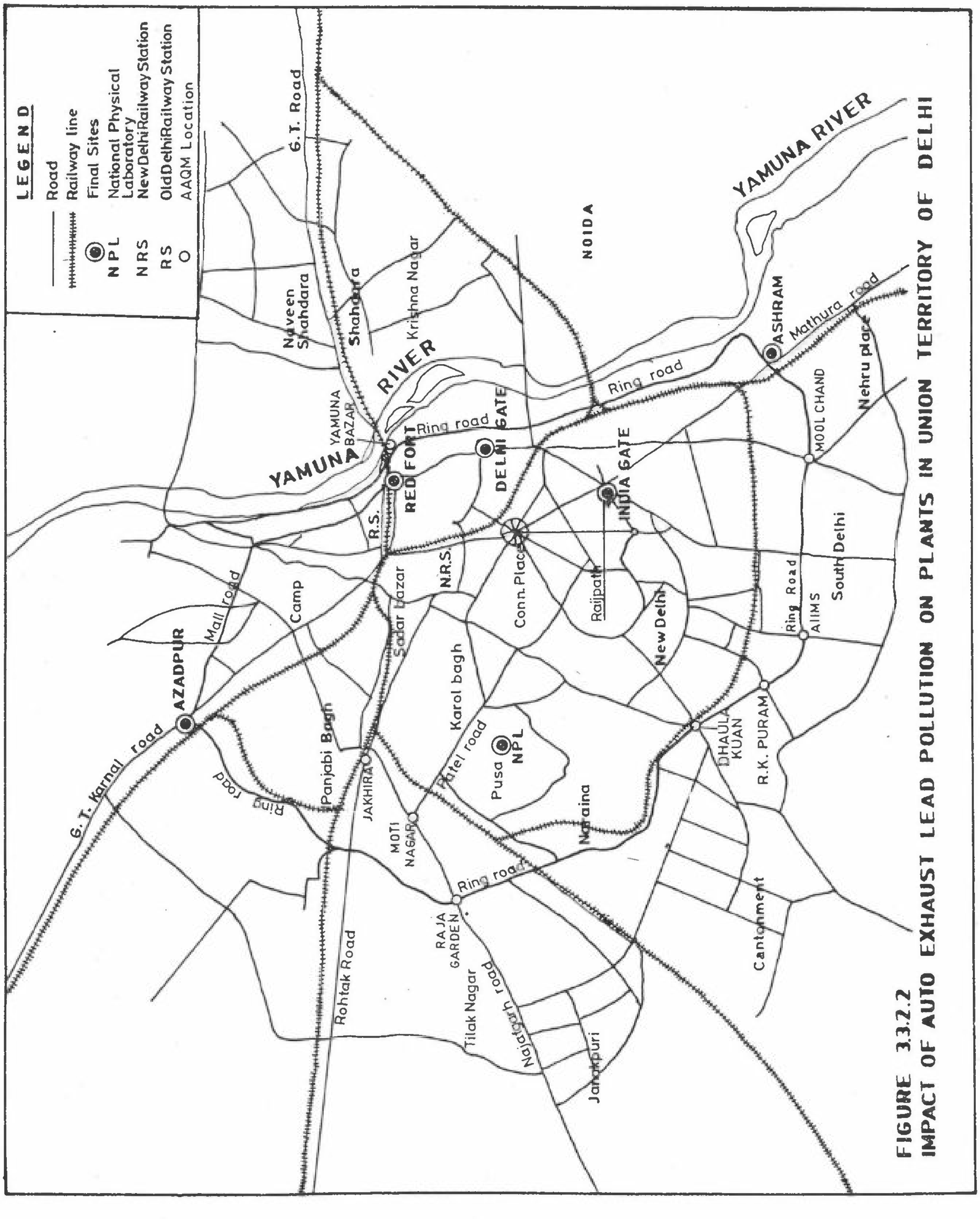


FIGURE 3.3.2.2
IMPACT OF AUTO EXHAUST LEAD POLLUTION ON PLANTS IN UNION TERRITORY OF DELHI

25

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APPENDIX J

Emissions from stone crushers (Sohna area)

APPENDIX I

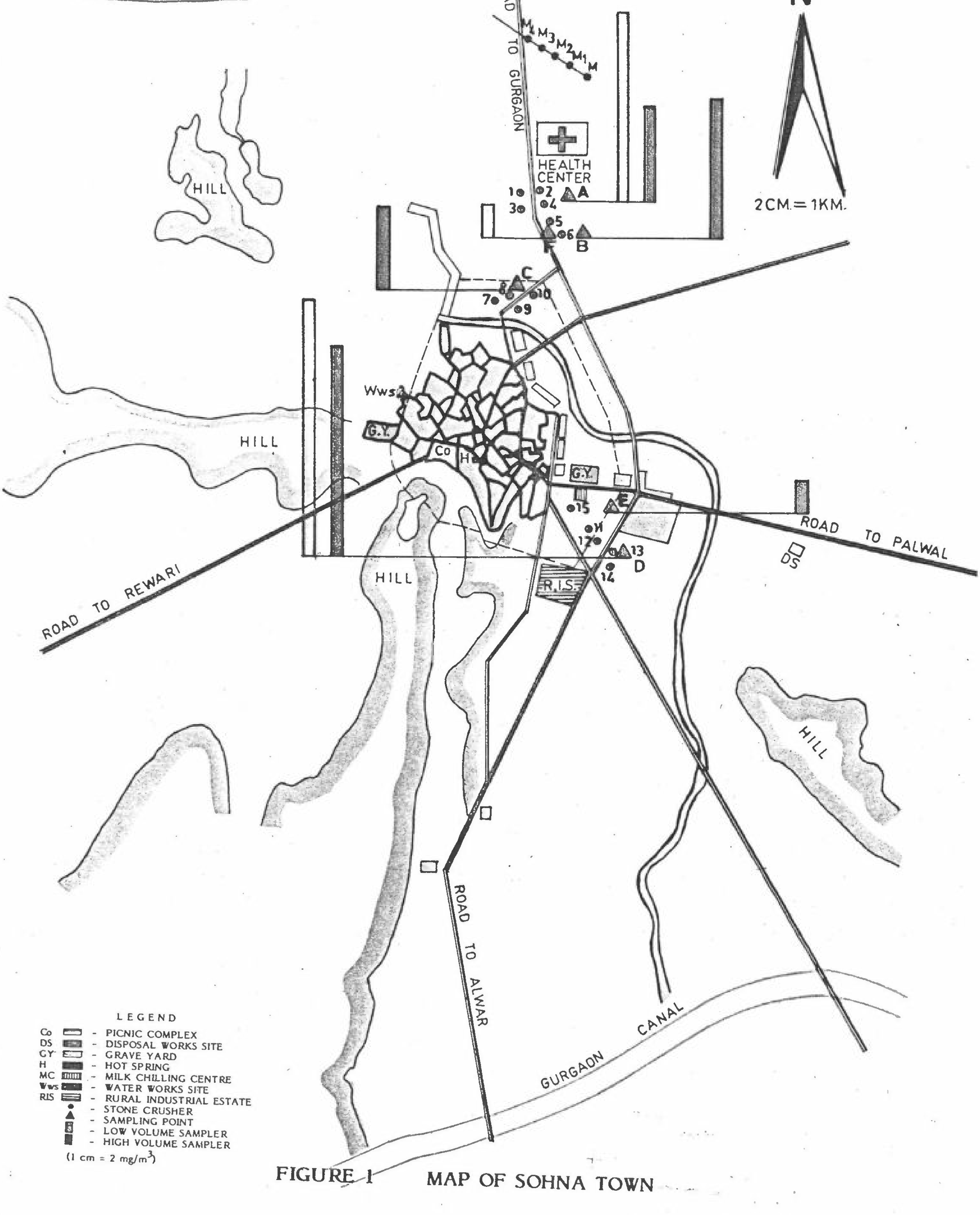

FIGURE 1 MAP OF SOHNA TOWN

Table 6.2

Comparison between theoretical and observed value of suspended particulate matter at different distances towards wind direction due to a single crusher of dust emission 2.8 MT/day at stability Class 'B'.

Sl. No.	Sampling station	SPM (µg/cu m)	
		Observed value	Theoritical values *
1.	At source M	10440	-
2.	M_1 (100 meters from M)	5900	6405
3.	M_2 (200 meters from M)	1750	1845
4.	M_3 (300 meters from M)	750	866
5.	M_4 (400 meters from M)	-	499
6.	M_5 (500 meters from M)	-	322

* obtained from Table 6.3, for stability Class B

Table 6.3

The surface concentration of suspended particulate matter (ug/cu m) at different distances from a crusher (M) of dust emission 2.8 MT/day at different stability classes

Wind speed 2 m/s — Effective stacks heights 0 metre

Stability class	Distance (meters)												
	100	200	300	400	500	600	800	1000	1200	1400	1600	1800	2000
A	3813	967	414	210	118	69	29	15	8	5	3	x	x
B	6405	1845	866	499	322	223	127	81	56	42	32	25	20
C	14242	4049	1907	1135	758	541	318	216	154	117	91	77	62
D	34180	10099	4899	2945	2034	1499	899	620	454	351	278	226	189
E	59909	18008	9063	5527	3790	2815	1761	1241	925	730	597	498	430
F	137002	41783	20856	12805	8827	6422	4013	2872	2172	1695	1377	1153	985

Stability class	Distance (meters)							
	3000	4000	6000	8000	10000	12000	16000	20000
A	x	x	x	x	x	x	x	x
B	9	5	2	x	x	x	x	x
C	30	18	9	x	x	x	x	x
D	95	58	29	x	x	x	x	x
E	240	160	90	60	45	35	24	18
F	558	375	218	150	114	90	64	49

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ABSTRACT (max. 300 characters, 7 lines)
A plan for establishing multiple source dispersion models in India has been developed based upon a visit to India by NILU in Nov./Dec. 1989. The plan includes collection of input data, model estimates for Delhi, training and demonstration of the use of models, and application of model systems in other areas of India.

* Kategorier: Åpen - kan bestilles fra NILU A
Må bestilles gjennom oppdragsgiver B
Kan ikke utleveres C