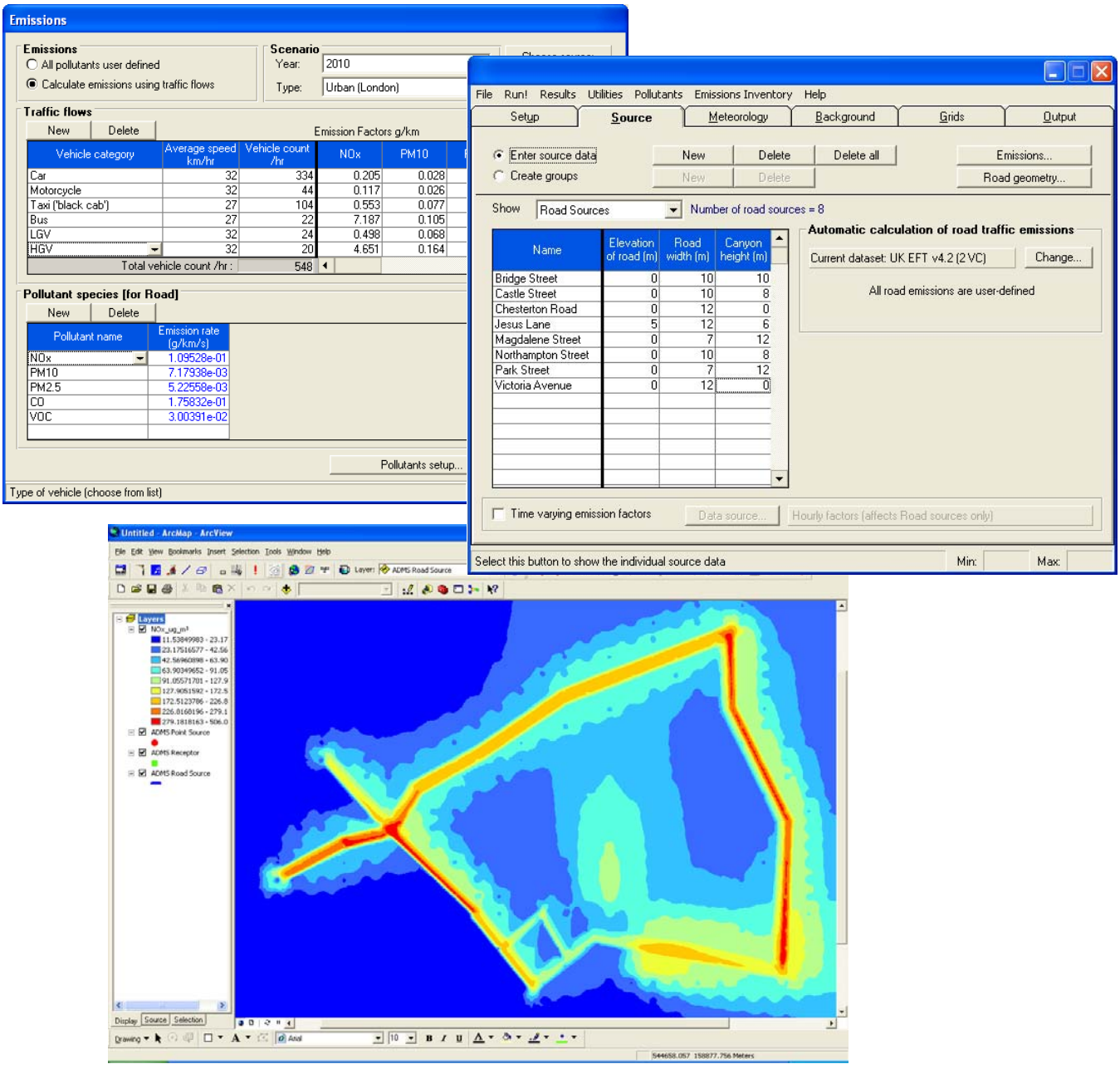
ADMS-Roads Extra

Air Quality Management System



User Guide CERC

ADMS-Roads Extra

An Air Quality Management System

User Guide

(A Supplement to the ADMS-Roads User Guide)

Version 3.1

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SECTION 1 Buildings

1.1 Model Options

1.1.1 Building effects

Chimney stacks often protrude from the roof of a building or are attached to the side of a building on industrial sites.

Buildings can have a significant effect on the dispersion of pollutants from sources and can increase the maximum predicted ground level concentrations. The main effect is to entrain pollutants into the cavity region in the immediate leeward side of the building, bringing them rapidly down to ground level. As a consequence, concentrations near the buildings are increased but decreased further away.

The buildings module in ADMS-Roads Extra allows the user to enter up to 10 buildings in any one run. However, this does not mean that this many buildings *should* be included in a given run and consideration must be given as to which buildings to include.

For each source, the program combines the individual buildings into a single effective building for each wind direction in the meteorological file, the height of which is the height of the building specified as the main building for that source. (This is described in more detail in Section 1.2.)

The effect of buildings on dispersion can only be modelled for point sources. Other types of sources may be included in the modelling run, but the effect of the buildings on dispersion from these sources will not be modelled. In order to model building effects for a line, area, volume or road source, the source should be modelled as a number of point sources.

1.1.2 Defining buildings

Select the Buildings button on the Setup screen and click Enter parameters... to go to the Buildings screen shown in **Figure 1.1**.

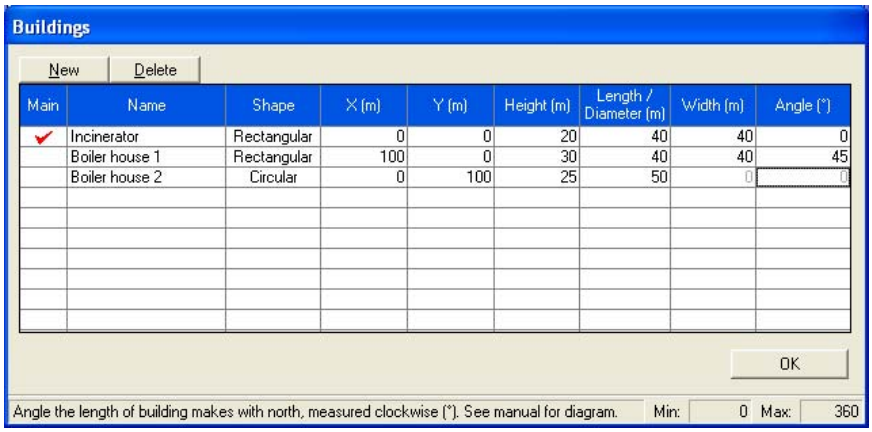

Figure 1.1 − The Buildings screen.

The user may add or remove buildings in the table using the New and Delete buttons, respectively. At least one building and up to 10 may be specified, each defined by the following parameters.

1. Main: The user must define one 'main building' by placing a tick in this column. This is likely to be the building that has the most significant effect on dispersion. To change the main building, double click in the Main column or type **Y** or **N** to display or remove the tick.

   Default = a tick appears next to the first building created.

   Note that the main building defined in this screen is the default main building. Source-specific main buildings are defined on the source screen (see Section 1.1.3 for further details).

2. Name: The model will use a default name when a new building is added (e.g. Building001). The user is advised to change this to something more meaningful (e.g. boiler house). Building names must not contain commas.

3. Shape: shape of the building, either Rectangular or Circular. To change the shape of the building click on the cell.

   Default = Rectangular.

4. X (m): X coordinate of the centre of the building
   Y (m): Y coordinate of the centre of the building

   Minimum = -9999999 m
   Maximum = 9999999 m
   Default = 0 m

   The large maximum value allows the user to input UK National Grid coordinates or worldwide UTM (Universal Transverse Mercator) coordinates. Note that the building position should be specified in the same coordinates as the source position and output grid.

5. Height (m): height of the building.

   Minimum = 0 m
   Maximum = 500 m

Default = 0 m

6. Length (m): length of a rectangular building or diameter of a circular building. For a rectangular building this is simply one horizontal dimension.

   Minimum = 0 m
   Maximum = 1000 m
   Default = 0 m

7. Width (m): width of a rectangular building, not necessarily smaller than the length. This parameter is not used for a circular building.

   Minimum = 0 m
   Maximum = 1000 m
   Default = 0 m

8. Angle (°): the angle between north and the previously defined Length, measured clockwise from north. This is not used for a circular building. See Section 1.2 for a diagram and more information.

   Minimum = 0°
   Maximum = 360°
   Default = 0°

1.1.3 Defining the 'main building' for each source

The user may specify a 'main building' for each point source, i.e. indicate which building is likely to have the most effect on dispersion from that source. **Figure 1.2** shows the Source screen for Industrial Sources when Buildings are selected in the Setup screen. In the Main building column for each source the user may select a building from the list that they would like to define as the Main building for that source. The list includes all the named buildings defined in the Buildings screen, as well as (Main) and (None).

If (Main) is chosen then the building defined as the Main building in the Buildings screen will be the main building for this source. This is the default selection.

If (None) is selected then building effects will not be modelled for this source. This might be useful, for example, where the user knows that a source lies outside the region of influence of all buildings and wishes to keep run-times to a minimum.

An entry for Main building is required if buildings are included in the model run.

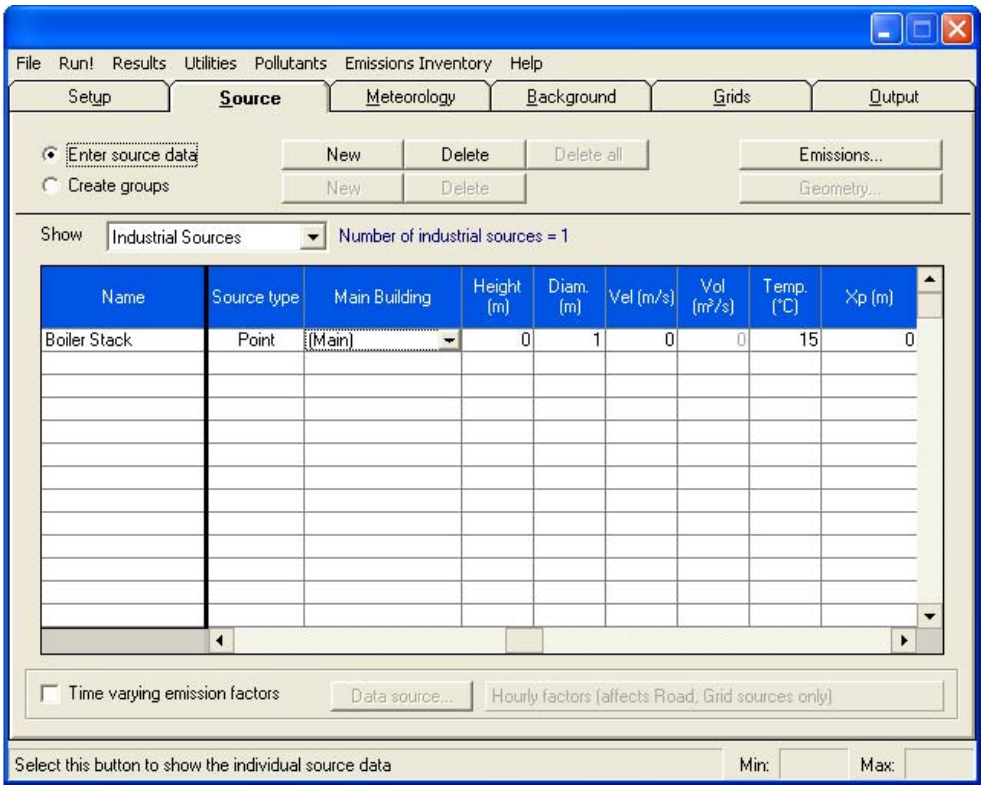

Figure 1.2 − The Source screen when a building is present.

1.1.4 Guidance

Wherever possible, a complicated site with a large number of buildings should be simplified. The user should consider the building or buildings to which the sources are attached or to which they are nearest.

A few hints and tips for modelling buildings are listed below.

- Buildings such that $\alpha H < Z_s$, where $\alpha = 1 + 2*min(1,W/H)$, where H is the height of the building, W is its crosswind width, and Z_s is the source height, are ignored when setting up the effective building, so need not be entered.
- Where there is a cluster of similar buildings on a site such as a row of warehouses, the user may decide to enter them as a single building.
- If there are a large number of buildings on a large site, the user should consider whether to include those that are nearest to/attached to the sources and/or those that will have the greatest effect on dispersion (tallest/largest), or consider a higher surface roughness, which can be entered in the Meteorology screen, as a means of representing the buildings in a complex site.
- The effect of buildings on dispersion can only be modelled for point sources. Other types of sources may be included in the modelling run, but the effect of the buildings on dispersion from these sources will not be modelled. In order to model building effects for a line, area, volume or road source, the source should be modelled as a number of point sources.
- Sources inside buildings cannot be modelled, though sources on the sides or

roof of a building can be modelled.

1.1.5 Outputs: *.bef*, *.bld* and *.bwk* files

These files are related to the Buildings module.

The *.bef* file (effective building) contains the coordinates of the effective building for each source and line of meteorological data.

The *.bld* file (buildings) contains the dimensions of buildings input to the model as well as some parameters calculated during the run (including the region affected by the presence of buildings, the cavity and cavity concentration). Output values are usually given for the first 24 lines of meteorological data only, in order to prevent the file from becoming too large. However, the file can be extended if required, as described in Section 5.1.13 of the ADMS-Roads User Guide.

1.2 Technical Summary

The building effects module is used to calculate the dispersion of pollution from sources near large structures. The ADMS-Roads Extra model of building effects has the following features.

- Up to 10 cuboidal or cylindrical buildings are defined by the user in terms of their height, length, width and orientation (latter two parameters are disregarded for cylindrical buildings). A main building is defined for each source (refer to Section 1.1.3 for advice on the choice of main building.) Then, for each wind direction the buildings are reduced to a single cuboidal effective wind-aligned building whose height is a function of the height of the main building (see Section 1.2.1).
- The disturbed flow field consists of a recirculating flow region or cavity in the lee of the building, with a diminishing turbulent wake downwind.
- Concentrations within the well-mixed recirculating flow region are uniform and based upon the fraction of the release that is entrained.
- The concentration at a point further downwind is the sum of two contributions: a ground-level plume from the recirculating flow region and an elevated plume from the non-entrained remainder. The turbulent wake reduces plume height and increases turbulent spread.
- The concentration and deposition are set to zero within the user-defined buildings.

The building effects module interacts with the rest of ADMS-Roads Extra, using the underlying concentration profiles, but with modified plume height and plume spread. The stages in the analysis of building effects are illustrated in **Figure 1.3**, while **Figure 1.4** shows how a complex of buildings is treated.

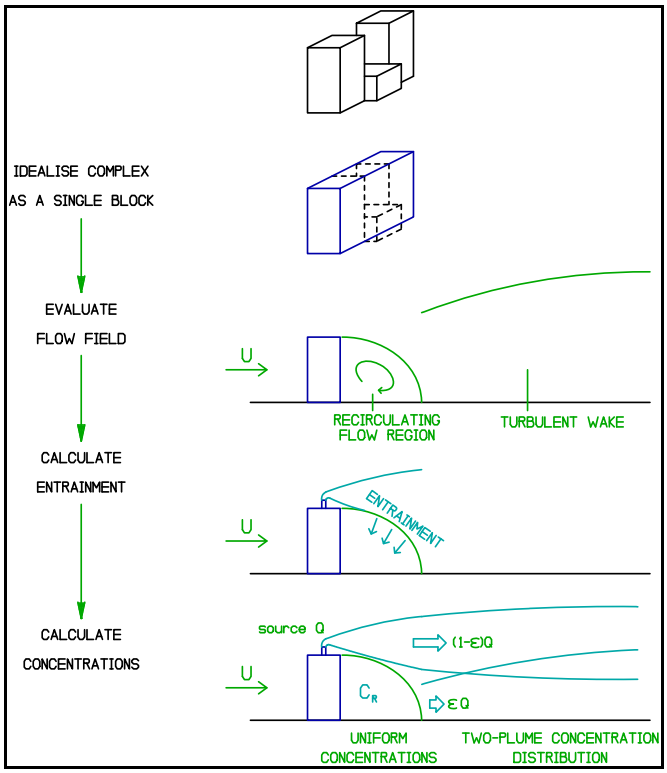

Figure 1.3 – Stages in the analysis of building effects.

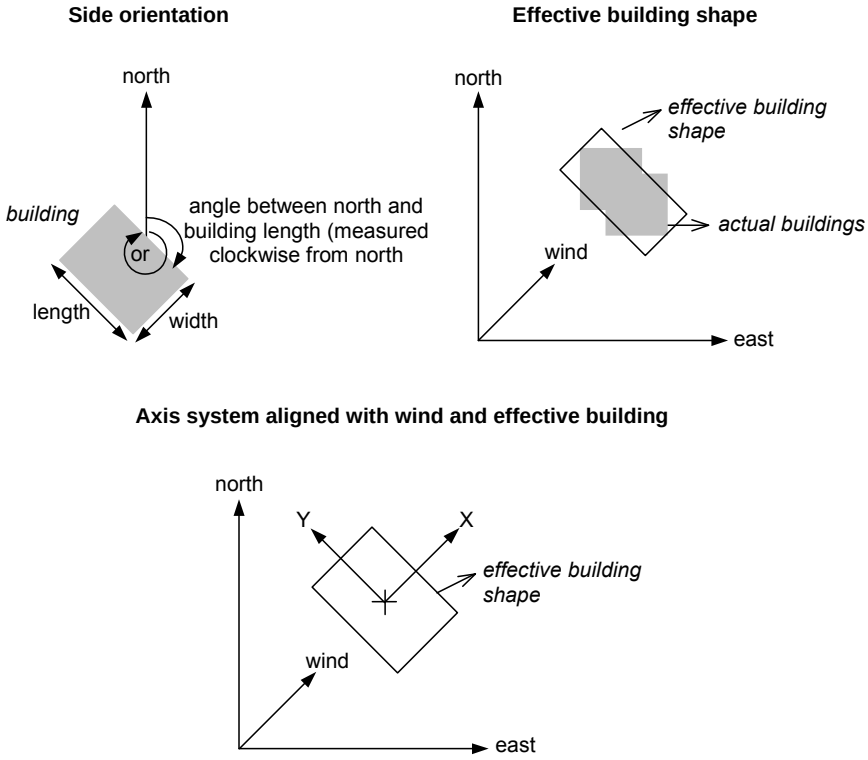

Figure 1.4 – Building effects module definitions.

1.2.1 Determination of the 'effective building'

The effective building is derived by the following algorithm:

1. Circular buildings are converted to 'equivalent' square blocks, with the same centre as the input circular building and side length $D_i/\sqrt{2}$, oriented such that the wind is normal to the building face.

2. Any buildings of height less than a fraction $1/\alpha$ of the source height are ignored, where

$$\alpha = 1 + 2\min\left(1, \frac{W_i}{H_i}\right) \tag{1.1}$$

   where W_i is the crosswind width of building i.

3. Any buildings that are greater than a certain distance from the plume centreline in the crosswind direction are ignored.

   Specifically, a building will be ignored if all its vertices are greater than $0.5\,\sigma_y(|x|)$ from the plume centreline in the crosswind direction, where x is distance from the source in the alongwind direction, and $\sigma_y(x)$ is the horizontal plume spread (not including building effects) at distance x downwind of the source (see example in **Figure 1.5**).

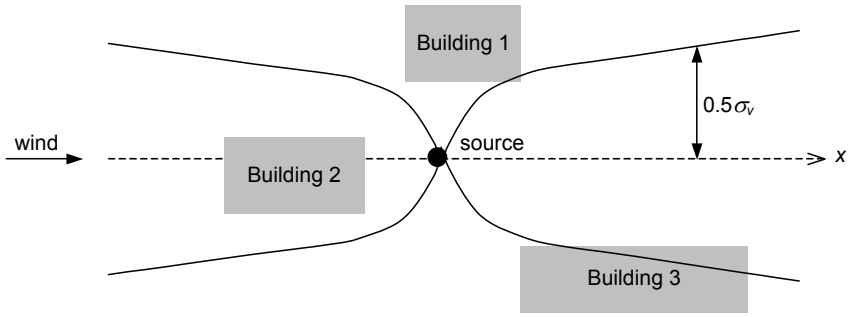

Figure 1.5 – Example source and building configuration. Buildings 2 and 3 will be included in the effective building, but building 1 will not.

4. The user specifies which is the main building; H_B and θ_B are the height and orientation of this unit.

   Multiples of 90° are added or subtracted until $-45° < \theta_B \leq 45°$. A different main building may be selected for each source. If the main building is not tall enough to be considered, according to 2 above, then no buildings are modelled for that source. If the main building is too far from the plume centreline, according to 3 above, then an alternative main building is automatically selected. The new main building will be that with its centre closest to the source, of those that are able to modelled according to 3.

5. A subset Σ is then defined by the main building plus all other buildings (a) that are at least $0.5\,H_B$ high and (b) whose projected crosswind and along-wind separations from another subset member do not exceed half the projected crosswind width of the main building.

6. In the general case where Σ includes more than one building, W_E is the projected crosswind width and L_E is the along-wind projection from the furthest upwind mid-face to the furthest downwind mid-face (see **Figure 1.6**).

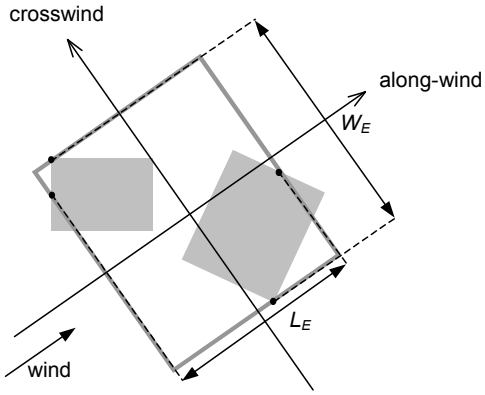

Figure 1.6 – Effective building for case where Σ includes two buildings. The grey shaded rectangles represent the user-input buildings and the grey open rectangle represents the effective building.

7. In the special case where Σ only includes one building, $L_E = min(L_F, L_D)$ where L_D is the along-wind length of the building, as seen when travelling along the wind direction, and L_F is the along-wind projection from the furthest upwind mid-face to the furthest downwind mid-face described in 6 (see **Figure 1.7**).

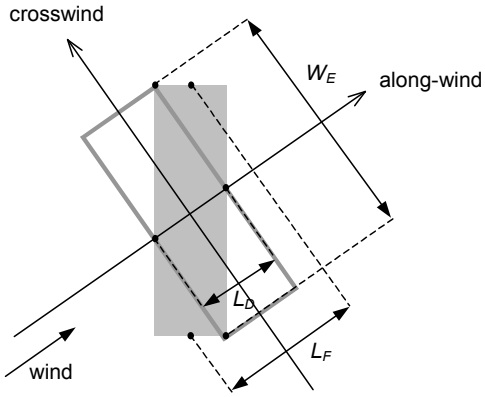

Figure 1.7 – Effective building for case where Σ only includes one building. The grey shaded rectangle represents the user-input building and the grey open rectangle the effective building.

1.2.2 Limitations

The buildings module is based on experiments in which there was one dominant site building and several smaller surrounding buildings less important for dispersion.

APPENDIX A Model Limits

The types of source available (Point, Line, Area, Volume, and Road) are described in Section 3.2 of the ADMS-Roads User Guide. Overall restrictions are as follows.

- The maximum number of road sources is 600 each with up to 50 vertices (i.e. over 25000 roads links).
- The maximum number of industrial sources is 65 (25 point, 5 line, 10 area and 25 volume sources).
- The maximum number of groups that can be created and run in one *.upl* file is 5.
- The maximum number of pollutants that can be entered into the pollutant palette is 31. The number of pollutants that may be emitted by any source, or included as output from the model, is 12.

Table A.1 shows which model options can be used with each type of source, and with multiple sources.

Model option	Point source	Line, area or volume source	Road sources
Deposition	✓	✓	✓
Chemistry	✓	✓	✓
Complex terrain	✓	✓	✓
Buildings	✓	[1]	[1]
Time-varying sources	✓	✓	✓
Odours	✓	✓	✓

Table A.1 − Availability of model options with different source types.

1. Line, area, volume, road and grid sources and buildings can be in the same run but the effect of the buildings will be ignored for these sources.

Short-term output is available both with single and multiple source output. Line plotting output is only available with single source, short-term gridded output. Long-term output is not available with single source output, the groups option must be selected on the Output screen if long-term output is required.

To calculate long term output for a single source, create a group containing just that source and select that on the Output screen.

All Model options on the Setup screen can be used together, with the exception of Odours which cannot be used with the Chemistry option. In addition, when the Odours option is selected, the 'Calculate emission using traffic flows' option for road sources cannot be used.

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