Urban air quality impacts from a road widening scheme

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Introduction - road widening schemes

• Road widening schemes in urban areas are often proposed as a solution to traffic congestion and as a means of stimulating economic growth.

• The impact of such schemes on air quality is mostly addressed by pre-scheme modelling and they are seldom validated by measurements after the expansion of road capacity.

• Construction is an acknowledged source of PM and can have a temporary impact on local air quality which can be overlooked in Environmental Impact Assessments (e.g. Fuller and Green, 2004).
Introduction – construction emissions

- Compared to other sources little is known about construction emissions.
- Construction has become an important factor in the new LAEI (2010) especially with respect to exhaust emissions from machinery which are predicted as 10-15x construction.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>NRMM from Construction</th>
<th>Construction and demolition</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO\textsubscript{x}</td>
<td>11.6%</td>
<td>0%</td>
<td>11.6%</td>
</tr>
<tr>
<td>PM\textsubscript{10}</td>
<td>11.6%</td>
<td>1.3%</td>
<td>12.9%</td>
</tr>
<tr>
<td>PM\textsubscript{2.5}</td>
<td>16.5%</td>
<td>0.8%</td>
<td>17.3%</td>
</tr>
</tbody>
</table>

- PM Emissions Factors (EF) are available from US EPA (1995), expressed as emissions rate per disturbed area per month of activity.
- For UK, APEG (1999) took US EPA figures and halved them because it rains more here. Factors are also available from CEPMEIP-Europe and NAEI.
Introduction – the road scheme

• Duelling 1.8 km of the A206 Thames Road in Bexley to **reduce delays and regenerate the area**, the second-largest industrial area in London.

• Environmental Statement: air quality during the construction phase not considered (despite movement of 45,000 m³ of material) but traffic and dispersion modelling (EPA CAL3QHC) undertaken to evaluate the impact **after completion** of the road works:
  - increase of the traffic flow of 19% and 9% in the morning and evening peaks
  - but “marginal” changes in air quality

<table>
<thead>
<tr>
<th>Location</th>
<th>Before</th>
<th>After</th>
<th>Increment (After-Before)</th>
</tr>
</thead>
</table>
| **Annual mean PM$_{10}$ (µg m$^{-3}$)**
  The Jolly Farmers | 28.4   | 28.4  | 0                        |
  Iron Mill Lane    | 27.9   | 28.0  | 0.1                      |
| **No. days daily PM$_{10}$>50 µg m$^{-3}$**
  The Jolly Farmers | 31     | 31    | 0                        |
  Iron Mill Lane    | 31     | 32    | 1                        |
| **Annual mean NO$_{2}$ (µg m$^{-3}$)**
  The Jolly Farmers | 40.0   | 39.2  | -0.8                     |
  Iron Mill Lane    | 36.8   | 37.0  | 0.2                      |
Study aims

• To determine the \textit{air quality impacts} of a large \textit{road construction project} in a residential area (air pollutants and oxidative potential)

• To \textit{determine emission factors} from the construction activity for use in subsequent environmental impact assessment.
Methods

Study area: A206 Thames Road widening, Bexley

a)

b)
Methods

Instrumentation and data

- $\text{NO}_x, \text{NO}_2$ by chemi-luminescence (API 200E)
- $\text{PM}_{10}$ (TEOM VCM) and $\text{PM}_{2.5}$ TEOM (Green, 2009)
- OP on the TEOM filters at AQMS-S (residential site)
- Traffic data from DfT and TfL counters (7-18 h)
- Met measurements from onsite at AQSM-N
- Three 17 month time periods- before / during /after construction
Methods

Calculations

I) **Isolating road derived pollution increment** as air blows across the road

\[ C_r = C - C_u \]

II) **Source apportionment** of PM into primary and non-primary using NO\(_X\) as tracer for primary PM (Fuller et al, 2002; Fuller and Green, 2006)

\[ [C_r \text{ PM-NO}_X\text{-related}] = A \times [C_r \text{ NO}_X] \]

\[ [C_r \text{ PM-fugitive}] = [C_r \text{ PM}] - [C_r \text{ PM-NO}_X \text{ related}] \]

with \( A \) being an emissions ratio from local increments before and after the construction
Methods

III) *Emissions factors* from box modelling

\[ F_{\text{lateral\ in}} + F_{\text{road}} = F_{\text{lateral\ out}} \]

\[
EF_{\text{road}} = \frac{U \cdot H \cdot C_r \cdot PM_{10}}{W}
\]

\[
EF_{\text{traffic}} = \frac{U \cdot H \cdot (A \cdot C_r \cdot NO_x)}{W}
\]

\[ U = WS \cdot \cos(WD-\alpha) \]

where \( \alpha \) is the angle between the road direction and the north (49 deg)
Results

I) Traffic data

After...

- Total flow +34% and +29% in the morning and evening peaks

- Cars +11% and taxis +19% especially at rush hour (+32-+49%)

- LGVs +60% @6 am; 12-18% 2-4 pm).

- Lower number of HGVs after completion of the road works
Results

II) Mean Daily Pollution from the road

PM$_{10}$ EU LV breached during construction
NO$_{2}$ LV breached at north site during and after construction

Brackets denote increments above background
Results

III) Fugitive PM vs meteorology

Above average on warm, dry and windy days
Below average when damp – would CMA or wet suppression help?
## Results

### IV) Emissions factors

<table>
<thead>
<tr>
<th></th>
<th>Median $PM_{10}$ EF$_{construction}$</th>
<th>Worst conditions $PM_{10}$ EF$_{construction}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thames Road (this study)</td>
<td>0.9</td>
<td>10.5</td>
</tr>
<tr>
<td>NAEI (UK)$^a$</td>
<td>0.7</td>
<td>----</td>
</tr>
<tr>
<td>CEPMEIP (Europe)$^b$</td>
<td>6.8</td>
<td>44.8</td>
</tr>
<tr>
<td>EPA (US)$^c$</td>
<td>27.2</td>
<td>103.8</td>
</tr>
</tbody>
</table>

$^a$NAEI (2011)

$^b$EMEP_EEA (2013)

$^c$EPA (2011)
Results

V) PM$_{10}$ oxidative potential @ AQMS-S

Glutathione dependent OP related to traffic sources, vehicular abrasion

Ascorbate dependent OP related to regional sources

No changes in PM$_{2.5}$ OP
Conclusions

• The increase of pollutants (PM$_{2.5}$ at peak times, NO$_X$ and NO$_2$) after the road was completed was mainly attributed to a higher number of cars and taxis and to a lesser extent to LGVs. During the rush hour peaks for PM$_{10}$ +2-4 µg m$^{-3}$, PM$_{2.5}$ + 1 µg m$^{-3}$, NO$_X$ + 40 µg m$^{-3}$ and NO$_2$ + 8 µg m$^{-3}$ above the levels before the construction works. Increase in primary NO$_2$ emissions will also have been a factor.

• PM$_{10}$, but not PM$_{2.5}$ glutathione dependent oxidative potential was increased after the road widened consistent with an increase in pro-oxidant components in the coarse mode, related to vehicle abrasion processes.
Conclusions

• The mean $PM_{10}$ EF calculated for the construction activity (0.9 kg $PM_{10}$ m$^{-2}$ month$^{-1}$) was similar that in the UK NAEI (0.7 kg $PM_{10}$ m$^{-2}$ month$^{-1}$). Worst $PM_{10}$ EF from Thames Road was smaller (4 and 10 times smaller) than the ones used in the European and US inventories.

• There was no clear evidence of NRMM exhaust emissions and the LAEI emissions ratios of NRMM to construction were certainly not supported.

• Water or CMA dust suppressants might by efficacious to control construction $PM_{10}$
Conclusions

• The transformation of Thames Road into a dual carriage-way road to improve traffic congestion and the local economy led to a deterioration in residential air quality during the construction and afterwards, especially during the rush hour peaks.

• The widened road attracted more cars and taxis and LGVs especially at rush hours and more than predicted.

• No increase in HGV traffic – decreases in line with national changes. Remains to be seen if it was successful at regeneration.

• Predicted AQ impacts very much under estimated the outcome and there is a clear need for post scheme analysis to feedback into pre-scheme assessments.
Thanks to all my colleagues at King’s who take part in the running of the London Air Quality Network, to Bexley Council for funding this project and to Evelyn Wonnacott for her comments on the draft project text.

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