Geob 402
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Assignment 3 – Gaussian Plume Modelling

Effective Stack Height (m)		Wind Velocity (m/s)	Ground Level Concentrations (µg/m3) At 10 km downwind						Highest Concentrations (µg/m3)					
For A,B,C,D	For E,F		A	B	C	D	E	F	A (at 0.5km)	B (at 0.5km)	C (at 0.8km)	D (at 1.5km)	E (at 1.5km)	F (at 3km)
146	45	1	1	1	4	12	42	75	**51**	18	15	4	**213**	**120**
79	45	3	0	0	1	5	14	25	36	**48**	**43**	**27**	71	40
65	45	5	0	0	1	3	8	15	24	38	35	24	43	24
59	45	7	0	0	1	2	6	11	18	30	27	20	30	17
56	45	9	0	0	0	2	5	8	14	24	22	17	24	13
54	45	11	0	0	0	2	4	7	12	21	19	14	19	11
53	45	13	0	0	0	1	3	6	10	18	16	12	16	9
52	45	15	0	0	0	1	3	5	9	16	14	11	14	8
51	45	17	0	0	0	1	2	4	8	14	13	10	13	7
50	45	19	0	0	0	1	2	4	7	13	12	9	11	6
50	45	21	0	0	0	1	2	4	6	11	11	8	10	6

Fig. 1. Data from Gaussian plume model for Ground Level Concentrations (GLC) at 10km downwind of source, and highest concentrations for stability classes A to F. (A- Very Unstable, B- Moderately Unstable, C- Slightly Unstable, D- Neutral, E- Somewhat Stable, F- Stable)

	Concentration (µg/m3)					
Height (m)	A	B	C	D	E	F
0	**0.0167**	**0.9535**	**3.7646**	**12.2967**	**43.7358**	**80.4841**
25	0.0167	0.9533	3.7602	12.3395	42.2549	79.424
50	0.0167	0.9529	3.7472	12.4473	38.0629	72.1373
75	0.0167	0.9521	3.7256	12.5637	31.8679	54.609
100	0.0167	0.9509	3.6956	12.6094	24.6898	32.2864
150	0.0167	0.9478	3.6111	12.1699	11.5201	4.8731
200	0.0167	0.9433	3.496	10.7235	3.7375	0.23
250	0.0167	0.9377	3.3534	8.4063	0.8239	0.0034
300	0.0167	0.9308	3.187	5.7857	0.1218	0
400	0.0167	0.9135	2.7994	1.8157	0.0008	0

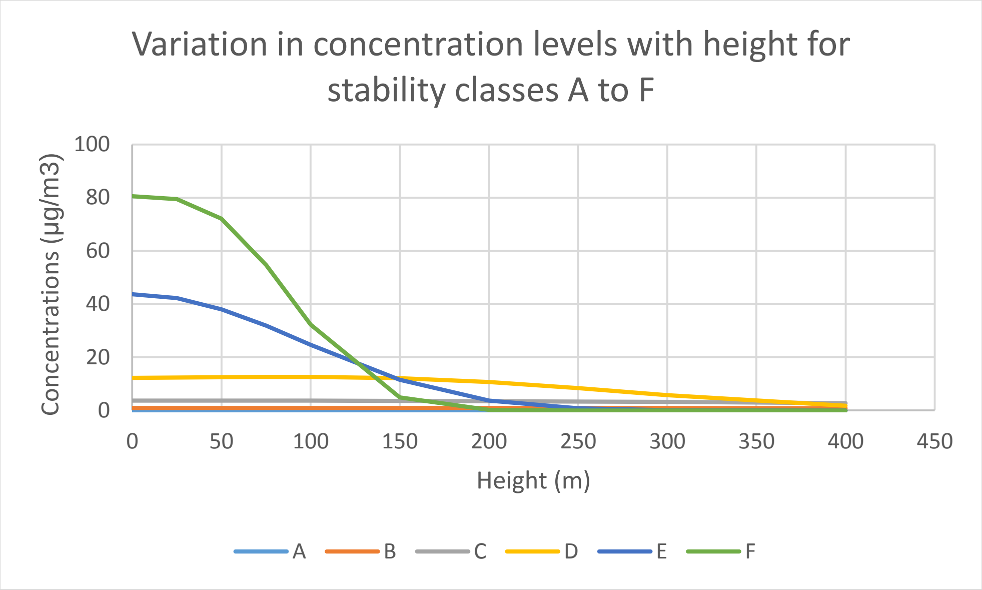

Fig. 2. Table and graph showing highest concentration in bold and changes in concentrations with height for different stability conditions (A to F), from Gaussian Dispersion Calculator.

The graph in Fig. 2 shows that the highest concentrations occurs at ground level (0m), and decreases with height (especially for the more stable classes). If a plume was intercepted by an obstacle (e.g. Sumas Mountain) at 10km downwind from the source, it will result in plume impingement and the concentration levels will be highest at ground level. Ground level concentrations are the highest during the more stable conditions, since more pollutants can accumulate at the ground level after the plume is impinged by the obstacle. The concentration at the peak of Sumas Mountain (400m) is close to 0 for all stability classes. Most of the pollutants would not have made it to the peak of the mountain, and would have been diluted and dispersed around 150m. There is more variation with height for stable conditions, due to higher concentrations near ground level. Unstable conditions have relatively low concentrations throughout, as there is more dispersion and mixing closer to the stack source and results in lower concentration of pollutants at further distances away (i.e. 10km).

The predicted concentrations decreases with atmospheric stability. Looking at fig.1, we can see that the highest ground level concentrations at 10km downwind from the source occurs in the stable condition (F), which is 75 $\mu g/m^3$. Under stable atmospheric conditions, the smoke plume tends to have an anisotropic coning dispersion and there is less convective mixing of the pollutants. Therefore, concentrations tends to be higher near the ground level, especially under light wind conditions. For more unstable conditions (e.g. A, B, and C), concentrations of pollutants are significantly lower. The concentration observed at 10km downwind is close to 0 for the more unstable classes, as most of the pollutants would have been dispersed or mixed due to the higher convective mixing in unstable conditions. The predicted concentrations were also significantly higher at lower wind speeds (< 5 m/s), as there is less dispersion and advection by wind. Highest concentrations were predicted to be much closer to the source (between 0.5 to 3km) as compared to 10km downwind, and can go up to 120 $\mu g/m^3$ and 213 $\mu g/m^3$. As mentioned by McKendry (2000), it is not rare in the Lower Fraser Valley (LFV) to see spikes in hourly concentrations of PM10 that may exceed

200 µg/m^3, especially during light winds conditions with the development of a stable nocturnal boundary layer. This corresponds with the predicted maximum concentrations by the model.

British Columbia's (BC) acceptable daily concentration of PM 10 is 50 µg/m^3 is based on an 24-hour rolling average, which may obscure the short term peak values in concentrations due to the 'arrow head' diagram in the averaging of raw values. Therefore, we have to take into account that the CWS of 50 µg/m^3 is a daily average. The majority of the predicted concentrations at 10km does not exceed 50 µg/m^3, with the exception of class F. This supports the observed concentrations that are usually seen in the LFV (McKendry, 2000). With a wind speed of 1m/s and a class F stability, the predicted concentration was 75 µg/m^3 which exceeds50 µg/m^3 (Fig. 1). The median values for PM10 concentrations from McKendry's study seen in figure 2 are relatively low, between 10 to 20 µg/m^3 (McKendry, 2000). The observed values of PM10 concentrations in the LFV are relatively low, with peak concentration usually coinciding with the morning and evening rush hour (McKendry, 2000). The predicted values from the model at 10km appears to correspond to the range of values that were observed in the LFV. The maximum predicted value of 75 µg/m^3 is not uncommon in the hourly values observed, but is considered to be an outlier when compared to the median range of values (McKendry, 2000).

Reference

McKendry, I. G. (2000). PM10 levels in the lower fraser valley, british columbia, canada: An overview of spatiotemporal variations and meteorological controls. *Journal of the Air & Waste Management Association (1995)*, *50*(3), 443.