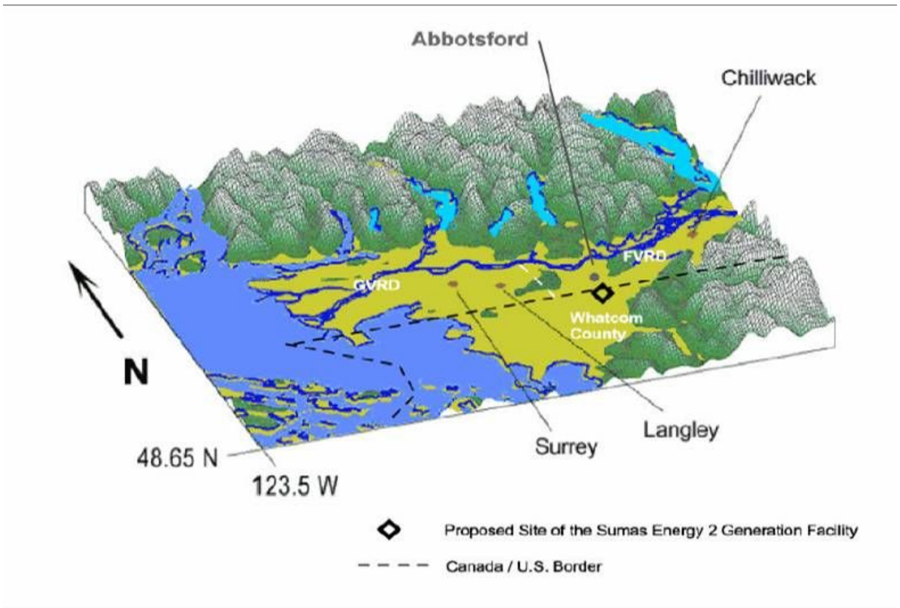
Assignment 3: Gaussian Plume Modelling



SUMAS 2 was an electric power plant proposal in the town of Sumas, Washington near the Canadian-United States border. The proposal was highly controversial due to natural gas use for power and the potential for pollutants to drift upwards into the Canadian Sumas Mountains, and further into the Lower Mainland of British Columbia including metro Vancouver.

The Gaussian Plume Dispersion Model is a mathematical model used to estimate the concentration of pollutants at a point at some distance for the source of emission [1]. Air pollution is represented by an idealized plume coming from the top of a stack with height and diameter. The Pasquill Stability classes are defined from A - G where: A - Extremely unstable conditions, B - Moderately Unstable conditions, C - Slightly Unstable Conditions, D - Neutral Conditions, E - Slightly Stable Conditions, F - Moderately Stable Conditions, G - Extremely Stable Conditions [2]. This model can help produce a set of scenarios for Ground Level Concentrations (GLCs) - 10 kms were used as the maximum downwind distance.

Looking at the tables, classes A - D show predicted concentrations decreasing with stability. Highest concentrations were noted at stability class F (Stable) at a 1000m from the source with an effective stack height of 55m and wind velocity of 1 m/s. Highest concentrations were seen at stable classes, relatively close to the source and at lower wind speeds. If the plume was to be intercepted by the Canadian Sumas Mountains, then it is expected that the plume from the facility would be affected with concentrations being highest at the ground level. Looking at the Gaussian Calculator runs - all concentrations drop to 0 at 400 meters indicating that plume impingement does occur and that there is no concentration at the peak of the mountains. A large majority of the pollutants are predicted to disperse or dilute by around 200 - 300 meters.

Unstable classes show the lowest concentrations through out which could be due to the effective mixing capabilities closer to the source which results in fewer pollutants further away from the source stack. On the other hand, stable classes tend to show higher concentrations (highest a few kilometers away from source and gradually decreasing further away). Significant concentrations were seen at lower wind speeds due to the poor dispersion and advection from lower velocities. Depending on insolation. A stable nocturnal boundary layer can affect the distance and maximum concentrations downwind.

The Lower Fraser Valley is an urbanized environment which experiences a significant PM10 pollution problem in the summer [3]. The paper highlights that during the study, provincial levels of ‘acceptable’ concentrations were around 50 ug/m^3. Looking at the concentrations graphs, it is clear that concentrations can exceeded these acceptable values. The LFV experiences daytime sea breezes in the summer which increases transportation of urban pollutants through the LFV [3]. This with the added pollution from SUMAS 2 could see higher concentration levels LFV.

Gaussian Plume Model Runs:

Stability Class A												
Very Unstable												
Wind Velocity	Effective Stack Height	Concentration at (meters)										
		0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
1	269	0	0	0	0	0	0	0	0	0	0	0
3	126	0	0	0	0	0	0	0	0	0	0	0
5	98	0	0	0	0	0	0	0	0	0	0	0
7	86	0	0	0	0	0	0	0	0	0	0	0
9	79	0	0	0	0	0	0	0	0	0	0	0
11	74	0	0	0	0	0	0	0	0	0	0	0
13	71	0	0	0	0	0	0	0	0	0	0	0
15	69	0	0	0	0	0	0	0	0	0	0	0
17	68	0	0	0	0	0	0	0	0	0	0	0
19	66	0	0	0	0	0	0	0	0	0	0	0
21	65	0	0	0	0	0	0	0	0	0	0	0

Stability Class B												
Moderately Unstable												
Wind Velocity	Effective Stack Height	Concentration at (meters)										
		0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
1	269	0	0	0	0	0	0	0	0	0	0	0
3	126	0	0	0	0	0	0	0	0	0	0	0
5	98	0	0	0	0	0	0	0	0	0	0	0
7	86	0	0	0	0	0	0	0	0	0	0	0
9	79	0	0	0	0	0	0	0	0	0	0	0

11	74	0	0	0	0	0	0	0	0	0	0	0
13	71	0	0	0	0	0	0	0	0	0	0	0
15	69	0	0	0	0	0	0	0	0	0	0	0
17	68	0	0	0	0	0	0	0	0	0	0	0
19	66	0	0	0	0	0	0	0	0	0	0	0
21	65	0	0	0	0	0	0	0	0	0	0	0

Stability Class C												
Slightly Unstable												
Wind Velocity	Effective Stack Height	Concentration at (meters)										
		0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
1	269	0	0	0	0	0	0	0	0	0	0	0
3	126	0	0	0	0	0	0	0	0	0	0	0
5	98	0	0	0	0	0	0	0	0	0	0	0
7	86	0	0	0	0	0	0	0	0	0	0	0
9	79	0	0	0	0	0	0	0	0	0	0	0
11	74	0	0	0	0	0	0	0	0	0	0	0
13	71	0	0	0	0	0	0	0	0	0	0	0
15	69	0	0	0	0	0	0	0	0	0	0	0
17	68	0	0	0	0	0	0	0	0	0	0	0
19	66	0	0	0	0	0	0	0	0	0	0	0
21	65	0	0	0	0	0	0	0	0	0	0	0

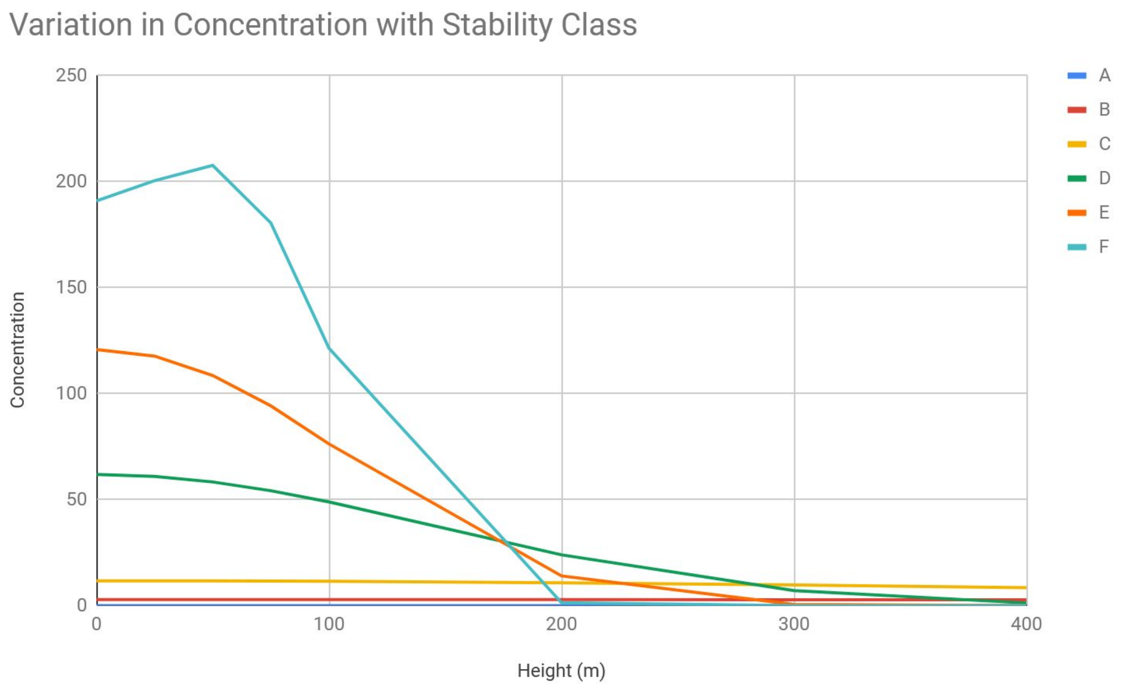
Stability Class D												
Neutral												
Wind Velocity	Effective Stack Height	Concentration at (meters)										
		0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
1	269	0	0	0	0	0	0	0	0	0	0	0
3	126	0	0	0	0	0	0	0	0	0	0	0
5	98	0	0	0	0	0	0	0	0	0	0	0
7	86	0	0	0	0	0	0	0	0	0	0	0
9	79	0	0	0	0	0	0	0	0	0	0	0
11	74	0	0	0	0	0	0	0	0	0	0	0
13	71	0	0	0	0	0	0	0	0	0	0	0
15	69	0	0	0	0	0	0	0	0	0	0	0
17	68	0	0	0	0	0	0	0	0	0	0	0
19	66	0	0	0	0	0	0	0	0	0	0	0
21	65	0	0	0	0	0	0	0	0	0	0	0

Stability Class E												
Somewhat Stable												
Wind Velocity	Effective Stack Height	Concentration at (meters)										
		0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
1	55	0	7	5	4	3	3	3	3	2	2	2
3	55	0	2	2	1	1	1	1	1	1	1	1
5	55	0	1	1	1	1	1	1	1	0	0	0
7	55	0	1	1	1	0	0	0	0	0	0	0
9	55	0	1	1	0	0	0	0	0	0	0	0
11	55	0	1	0	0	0	0	0	0	0	0	0
13	55	0	1	0	0	0	0	0	0	0	0	0
15	55	0	0	0	0	0	0	0	0	0	0	0
17	55	0	0	0	0	0	0	0	0	0	0	0
19	55	0	0	0	0	0	0	0	0	0	0	0
21	55	0	0	0	0	0	0	0	0	0	0	0

Stability Class F												
Stable												
Wind Velocity	Effective Stack Height	Concentration at (meters)										
		0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
1	55	0	13	9	8	7	6	5	5	5	4	4
3	55	0	4	3	3	2	2	2	2	2	1	1
5	55	0	3	2	2	1	1	1	1	1	1	1
7	55	0	2	1	1	1	1	1	1	1	1	1
9	55	0	1	1	1	1	1	1	1	1	0	0
11	55	0	1	1	1	1	1	0	0	0	0	0
13	55	0	1	1	1	1	0	0	0	0	0	0
15	55	0	1	1	1	0	0	0	0	0	0	0
17	55	0	1	1	0	0	0	0	0	0	0	0
19	55	0	1	0	0	0	0	0	0	0	0	0
21	55	0	1	0	0	0	0	0	0	0	0	0

Gaussian Calculator:

Height	A	B	C	D	E	F
0	0.0501	2.8747	11.7198	61.8643	120.8089	190.9286
25	0.0501	2.8742	11.7051	60.9647	117.703	200.4436
50	0.0501	2.8728	11.6613	58.3416	108.5861	207.6666
75	0.0501	2.8703	11.5887	54.2117	94.2336	180.4758
100	0.0501	2.8669	11.4877	48.9044	76.2703	121.4158
200	0.0501	2.8437	10.8188	23.9595	14.0261	1.395
300	0.0501	2.8055	9.7894	7.1323	0.5482	0.0001
400	0.0501	2.7528	8.5107	1.2623	0.0042	0



References:

[1] Gaussian Dispersion Model. Retrieved from
https://nptel.ac.in/courses/105101008/583_FuelEmi/point16/point.html

[2] READY Tools - Pasquill Stability Classes. Retrieved from
https://www.ready.noaa.gov/READYpgclass.php

[3] McKendry, I. (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*, *50*(3), 443-452. doi: 10.1080/10473289.2000.10464025