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Our ref: 2127652
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Dear Sir/Madam

Recreational Flight School
Air quality assessment

1 Introduction

GHD was commissioned by Sports Aviation Flight College Australia Ltd to undertake a desktop air quality assessment of the proposed recreational flight school at the existing Airfield in Bega Valley. This assessment provides an overview of potential emissions to air from the proposal, compares expected emissions with relevant criteria and describes any impacts in the local area.

The following scope of works was undertaken:

- Review of proposed operations, aircraft data and flying patterns
- Identification of potential emissions from the proposal
- High level emissions dispersion modelling to predict potential worst-case impacts
- Discuss any requirements or limits related to air quality

2 Project overview

The proposal is a recreational flight school to be located at the existing airfield in Bega Valley. The proposed location is sited on the western side of the Princes Highway in the locality of Frogs Hollow as shown in Figure 1.

2.1 Site location

The site is characterized within a rural area defined by surrounding agricultural land uses that includes cropping and grazing activities. It is zoned under infrastructure (SP2). The topography is gently undulating with scattered patches of residential structures.

The airfield has two existing runways, shown as primary and secondary in Figure 1. Earlier assessments suggest that the flight school will mainly use the primary runway while the secondary runway would be used as dictated by the prevailing conditions.

Figure 1 Location of proposed recreational flight school

2.2 Flying pattern

The flight school will be operating for 15 days a month during February to December. Subject to weather conditions, training will be conducted from Monday to Friday with limited remedial flying on a Saturday. When fully operational, 40 aircrafts will be operating each day.

For a flight day, there will be three training sessions per day starting at around 7:10 am, 10:50 am and 2:30 pm. The flying pattern will follow the standard flying cycle as shown in Table 1.

Table 1 Indicative flying cycle

Flight Mode	Description
Taxiing	Aircraft is moving slowly along the ground before take-off or after landing. A 20 meter wide taxiway is provided beside the primary runway with a length of approximately one kilometre.
Take-off	Aircraft is taking off one minute apart until all 40 aircrafts are flying. Duration of take-off is approximately two minutes until they reach the circuit
Climb out	Aircraft is in between take off and reaching 1000 feet

Flight Mode	Description
	Duration is approximately two minutes to reach 1000 feet Aircraft takes six minutes to complete a full circuit Maximum of six aircrafts can be in the circuit at once Circuit is at an elevation of 1000 feet
Cruising/training	Aircraft is in the designated training area for a two-hour training session. Air work in the training area is generally done at between 4,000 and 10,000 feet elevation. The training area is an airfield with a 46.25 kilometre radius Training may also be done over the ocean.
Landing	Aircraft are landing back to land 1 minute apart until all 40 aircrafts have landed. Duration of landing is approximately 2 minutes
Idle	When the engine is running but the aircraft is at a stop

2.3 Aircraft data

There will be three different types of aircraft for training purposes, namely the ‘Bantam’, ‘Trike’ and ‘Brumby’. These types of aircraft can be categorized under the sport aviation segment (i.e. ultralight aircraft, gliders, hang gliders and autogyros) of the general aviation sector. The aircraft that will be used predominantly throughout the flight training will be the ‘Bantam’.

These aircraft will be powered by a Rotax 912 UL/A/F piston aircraft engine. This piston engine has a capacity of 1,211 cubic centimetre and a compression ratio of 9.1:1. In a piston engine, the piston and crank mechanisms are used to extract the energy from fuel burnt in a combustion chamber. This drives the propellers to give the aircraft momentum.

The engines are fuelled by unleaded fuel similar to that of an automotive car. There are no plans to use aviation gas type of fuel.

3 Aircraft emissions

In estimating aircraft emissions, it is necessary to have data on the airport; number of landing/take-off (LTO) cycles; time spent in flying cycle; fuel used and type of engine.[1]

The emissions produced by aircraft mainly come from combustion of fuel. The ultra-light aircraft are similar to that of an on-road vehicle, except for the higher elevation and required speed for take-off. Pollutants emitted by aircraft are primarily:

- Particulate matters (PM) – general term for solids and liquid droplets found in the air. PM can cause respiratory problems to both humans and animals.
- Nitrogen oxides (NOx) – which includes nitrogen monoxide (NO) and nitrogen dioxide (NO_2) that react to form smog and acid rain and cause significant change in the ozone layer.
- Carbon monoxide (CO) – toxic to haemoglobin and causes oxygen deprivation in the blood.
- Hydrocarbons (HC) – organic compounds which are the primarily component of fuels.

For this assessment, only aircraft emissions from combustion of fuel are considered, however there will be other operations such as ground and maintenance work at the airport facilities with some minor emissions to air.

3.1 Estimated emissions

A Bantam aircraft running with a Rotax 912 piston engine was selected as basis for the choice and development of the emission rates as it will be predominantly used in the proposed flight school.

Available data on exhaust emissions of general aviation aircraft is limited, particularly for piston engines. In this case, the closest emissions levels available were obtained taking into consideration a more conservative emission.

Emission levels for a Rotax 912 piston engine was obtained from Exhaust Emissions from In-Use General Aviation Aircraft (Yacovitch 2016).[2] Two measurement platforms were used: the Aerodyne Mobile Lab (AML) supported instrumentation for gas-phase measurements; the Aerodyne trailer supported instrumentation for all particulate phase measurements.

The emission levels provided in Yacovitch 2016 are for aviation gasoline (avgas) only, while the flight school aircrafts will be running on unleaded fuel (mogas). Concentration of hydrocarbon compounds are generally higher in avgas than in mogas. The emissions in the study were also from a higher output 110 horsepower engine. GHD therefore considers the emissions used in the study to be conservative. Estimated emissions from the proposal are listed in Table 2 to Table 5.

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[1] National Pollutant Inventory. (2003). Emissions Estimation Technique Manual: Aggregated Emissions from Aircraft. Retrieved from http://www.npi.gov.au/system/files/resources/7c29f57e-fb3e-a0d4-e5f3-8e3b559d0f75/files/aircraft.pdf

[2] Yacovitch, T. et al. (2016). Exhaust Emissions from In-Use General Aviation Aircraft. Retrieved from http://energy.cleartheair.org.hk/wp-content/uploads/2016/11/24612.pdf

Table 2 PM Emission rates

Flight cycle	Emission index (g PM/kg fuel)	Fuel flow (kg fuel/s)	Emission rate (g PM/s)
Take-off	0.045	0.0033	0.000149
Climb-out	0.045	0.0033	0.000149
Cruise	0.026	0.0023	0.000060
Approach	0.005	0.0014	0.000007
Final Approach	0.005	0.0014	0.000007
Taxi	0.001	0.0010	0.000001
Idle	0.000	0.0006	0.000000

Table 3 NOx Emission rates

Flight cycle	Emission index (g NOx/kg fuel)	Fuel flow (kg fuel/s)	Emission rate (g NOx/s)
Take-off	4.8	0.0033	0.015840
Climb-out	4.8	0.0033	0.015840
Cruise	6.6	0.0023	0.015180
Approach	1.1	0.0014	0.001540
Final Approach	1.3	0.0014	0.001820
Taxi	1.0	0.0010	0.001000
Idle	1.3	0.0006	0.000780

Table 4 CO Emission rates

Flight cycle	Emission index (g CO/kg fuel)	Fuel flow (kg fuel/s)	Emission rate (g CO/s)
Take-off	808	0.0033	2.666400
Climb-out	808	0.0033	2.666400
Cruise	795	0.0023	1.828500
Approach	1,062	0.0014	1.486800
Final Approach	1,062	0.0014	1.486800
Taxi	819	0.0010	0.819000
Idle	816	0.0006	0.489600

Table 5 HC Emission rates

Flight cycle	Emission index (g HC/kg fuel)	Fuel flow (kg fuel/s)	Emission rate (g HC/s)
Take-off	79.0	0.0033	0.2607
Climb-out	79.0	0.0033	0.2607
Cruise	70.7	0.0023	0.1626
Approach	78.9	0.0014	0.1105
Final Approach	78.9	0.0014	0.1105
Taxi	87.8	0.0010	0.0878
Idle	100.9	0.0006	0.0605

4 Air quality criteria

4.1 NSW Approved Methods

In order to assess the suitability of the proposal, individual air pollutants were assessed against the impact assessment criteria at nearby sensitive receptors. In NSW, Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (EPA, 2016) provides guidance on undertaking air quality assessments and provides impact assessment criteria for pollutants. The impact assessment criteria is summarised in Table 6. These criteria apply to locations where people are likely to work or reside. Hydrogen fluoride criteria exists for land-use areas with vegetation sensitive to hydrogen fluoride such as grapevines and stone fruit, however the proposal is not a significant source of hydrogen fluoride and therefore has not been assessed.

Table 6 Assessment criteria

Pollutant	Averaging period	Criteria	Source
PM_{10}	Annual	25 µg/m^3	DoE (2016)
	24 hours	50 µg/m^3	DoE (2016)
Nitrogen dioxide (NO_2)	Annual	62 µg/m^3	NEPC (1998)
	1 hour	246 µg/m^3	NEPC (1998)
Carbon monoxide (CO)	8 hours	10 mg/m^3	NEPC (1998)
	1 hour	30 mg/m^3	WHO (2000)
Benzene	1 hour	0.029 mg/m^3	Victorian Government Gazette 2001
Toluene	1 hour	0.36 mg/m^3	Victorian Government Gazette 2001

Pollutant	Averaging period	Criteria	Source
m,p-Xylenes	1 hour	0.19 mg/m^3	Victorian Government Gazette 2001
N-Pentane	1 hour	33 mg/m^3	Victorian Government Gazette 2001

The Protection of the Environment Operations (Clean Air) Regulation 2010 (Clean Air Regulation) provides regulatory measures to control emissions from wood heaters, open burning, motor vehicles and fuels and industry. These relate to emissions at the source only. Aircraft used as part of the proposed facility would meet relevant Australian design and emissions standards.

5 Indicative dispersion modelling

An AUSPLUME modelling study consistent with EPA Approved Methods requirements has been used to assess aircraft emissions. This is effectively a screening level assessment with minimal meteorological data requirements and is generally used with conservative emissions data.

A Level 1 assessment of the individual impact the identified aircraft emissions was applied at sensitive receptors using applicable averaging periods. This means a screening-level dispersion modelling technique using worst-case input data was conducted. If a Level 1 assessment demonstrates that adverse impacts will not occur, there is no need for a more detailed air quality assessment.

5.1 Model inputs

The following inputs were developed to be very conservative (worst case) as prescribed for a Level 1 screening assessment under the EPA Approved Methods:

5.1.1 Meteorological data

The worst-case meteorological input considers all possible conditions which lead to poor dispersion and higher predicted ground level emission concentrations.

Lower wind speed would provide for less dispersion and higher concentrations near the airport area.

5.1.2 Emission rates

Emission data used in the model were discussed in Section 3.

5.1.3 Activity Data

A worst case modelling scenario was prepared based on provided plane movements and scheduling. Taking off produces the highest amount of pollutant per second among the flying cycle phases.

The proposed operation hours of 7:00 am to 6:00 pm (total of 11 hours) was used as start time and end time for this simulation. The worst-case modelled scenario was based on continuous take-off movements, each take off manoeuvre extending for two minutes and therefore an effective number of take offs as 330 aircraft. This is a lot higher than the proposed 120 aircrafts taking off per day making this modelled scenario overly conservative.

The following emission sources are included in the model:

- One plane assumed to be continually taking off (this represents a worst-case)
- One plane taxing on the runway
- One plane climbing out of the runway
- One plane training exactly above a receptor at an elevation of 500 feet above ground
- One plane landing into the runway
- One plane idling on the runway

The modelled scenario is a worst-case study, and predicted levels are a lot higher than those expected once operational. The model assumes the plane flying on a circuit is stationary (directly above key receptors) and would lead to greater predicted impacts on the receptor than is the emissions were spread out around an entire circuit.

5.1.4 Receptors

The nearest affected receptors surrounding the airfield were obtained from the noise assessment conducted for the proposal. This is considering the nearby residential structures, agricultural lands and natural vegetation. Additionally, existing lots that have potential for a future dwelling to be erected upon have also been identified as receptors. The location of the receptors are illustrated in Figure 2 .

Figure 2 Location of receptors

5.2 Modelling Results

The predicted ground level concentrations (GLCs) of identified pollutants in the receptors attributed to the aircraft emissions at the Recreational flight school are presented in the sections below. These are conservative worst-case emissions and are expected to be significantly higher than the actual operational impacts.

5.2.1 Maximum concentrations of PM, NOx and CO

The maximum GLC at the receptor alongside the EPA Approved Methods criteria are shown in Table 7 while the individual maximum GLS per receptor are tabulated in Appendix A.

Table 7 Maximum predicted PM NOx and CO concentrations

Pollutant	Averaging period	Criteria (µg/m^3)[a]	Maximum predicted GLCs (µg/m^3)	Percent of criteria
PM	Annual	25	1.3	5.2%
	24 hours	50	0.00794	0.0%
NOx	Annual	62	0.0544	0.1%
	1 hour	246	14	5.7%
CO	8 hours	10,000	725	7.3%
	1 hour	30,000	3,360	11.2%

a – criteria for PM is expressed as PM_{10} and NOx is expressed as NO_2

The maximum GLCs at the most effected receptor for PM, NOx and CO are below the impact assessment criteria set by NSW EPA. This implies that all GLC's at all the receptors are below the set limit.

It is important to note that the model has used several conservative (worst case) inputs to generate the maximum possible aircraft emission. Based on the tabulated results, it can be concluded that the concentration of pollutants from the aircraft emissions are insignificant.

5.2.2 Maximum concentrations of HC Compounds

HC are a complex mixture of toxic air pollutants. The composition of the HC exhaust was obtained from research on gasoline fuelled vehicles[3], as the flying school aircraft will be using unleaded fuel.

The major components were Benzene (5.0% of HC), Toluene (10.2%), m,p-Xylenes (6.5%) and N-Pentane (4.8%). These percentages were used to estimate their fraction of the total HC emissions

Maximum GLCs of each compound and the corresponding EPA Approved Methods limits are shown in Table 8 while the individual maximum GLS per receptor are tabulated in Appendix B.

[3] P.F. Nelson, S.M. Quigley. (1967). The hydrocarbon composition of exhaust emitted from gasoline fuelled vehicles, Atmospheric Environment. Volume 18, Issue 1, 1984, Pages 79-87. Retrieved from http://www.sciencedirect.com/science/article/pii/0004698184902300

Table 8 Maximum predicted hydrocarbon concentrations

Pollutant	Averaging period	Criteria (µg/m³)	Maximum predicted GLCs (µg/m³)	Percent of criteria
Benzene	1 hour	29	15	51.7%
Toluene	1 hour	360	30.6	8.5%
m,p-Xylenes	1 hour	190	19.5	10.3%
N-Pentane	1 hour	33,000	14.4	0.0%

The maximum GLCs for Benzene, Toluene, m,p-Xylenes and N-Pentene are below the impact assessment criteria. Results show that even with very conservative inputs, the predicted levels are well below the criteria.

6 Effects on nearby residents, agricultural land and native vegetation

At elevated concentrations, exposure to air pollution may cause a wide range of health effects. NSW Health states that these health effects 'vary from mild symptoms such as irritation of your eyes, nose and throat, to more serious conditions such as lung (respiratory) and heart (cardiovascular) diseases.'

However, the predicted pollutant concentrations from the proposal aircraft emissions using worst-case inputs are low in comparison against EPA Approved Methods criteria. Adverse impacts on humans are not predicted.

Air pollution that is known to impact vegetation and agriculture include particulates, flourides, sulphur dioxide and ethylene.[4] The proposal is not a significant source of these pollutants. Possible effects of identified air pollution to the agricultural land and vegetation are secondary damage in the form of minor distresses in their growth but can only take effect at high concentration level.[5] The predicted concentration levels are very low and adverse impacts on any local vegetation or agricultural land are not anticipated.

7 Conclusion

GHD has undertaken a desktop air quality assessment of the proposed Recreational flight school in Bega Valley. Potential aircraft emissions include PM, NOx, CO and HC compounds.

A dispersion modelling assessment has been undertaken using conservative inputs on the proposed aircraft type, flying schedule and potential emissions.

The predicted pollutant concentrations were assessed against the limits under the EPA Approved Methods which provides impact criteria applicable to locations where people are likely to work or reside.

[4] Encyclopedia Britannica. (2018). The Effects Of Pollution. Retrieved from https://www.britannica.com/technology/agricultural-technology/The-effects-of-pollution

[5] Gheorghe, Iuliana & Barbu, Ion. (2011). The Effects of Air Pollutants on Vegetation and the Role of Vegetation in Reducing Atmospheric Pollution.

In the worst-case modelled scenario, the maximum predicted pollutant concentrations are less than 12% of the impact assessment criteria for all pollutants except benzene. The worst case model prediction for benzene was below 52% of the ground level criteria at all receptor.

Hydrogen fluoride criteria exists for agricultural land and native vegetation. However, the proposal is not a significant source of hydrogen fluoride and therefore has not been assessed.

The proposal uses aircraft with engines similar to a small car and also runs on unleaded fuel, emissions around the site would be expected to be similar to those of a local road.

Based on the findings of this assessment, predicted emissions readily comply with ground level impact assessment criteria and would be acceptable from an air quality perspective. There are no expected impacts on nearby residents, agricultural land and native vegetation. The proposal does not require any specific mitigation measures in order to comply with air quality criteria.

Sincerely
GHD

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Evan is a senior environmental engineer (Bachelor of Engineering (Environmental), Griffith University, 2003) with more than 13 years' experience. He has specialist skills in air, noise and vibration assessment and a background in environmental management. Evan's work includes industrial sites required to meet emission limits of the POEO Regulations, assessments against impact assessment criteria in the NSW Approved Methods, odour impact assessment and mitigation, and construction dust assessments. Evan has prepared air quality management plans, monitoring programs and undertaken air quality and odour audits on behalf of private companies and regulators. Evan is proficient in the use of air modelling software including AUSPLUME, AERMOD, CALPUFF and TAPM.

Appendix A: GLCs at receptor points for NOx, PM and CO

	Nitrogen oxide (NOx)		Particulate matter (PM)		Carbon monoxide (CO)	
	1 hour	Annual	24 hours	Annual	1 hour	8 hours
EPA limit (ug/m^3)	**246**	**62**	**50**	**25**	**30,000**	**10,000**
Maximum GLC (ug/m^3)	**14**	**0.054**	**0.01**	**1.30**	**3,360**	**725**
Concentration at each receptor in descending order						
R1	14	0.054	0.008	1.3	3,360	725
R2	10.5	0.041	0.007	0.936	2,520	671
R3	10	0.04	0.007	0.926	2,430	630
R4	8.98	0.036	0.006	0.874	2,210	594
R5	8.24	0.027	0.005	0.625	1,980	560
R6	7.76	0.025	0.005	0.585	1,950	491
R7	6.98	0.024	0.004	0.576	1,650	446
R8	6.17	0.023	0.004	0.544	1,590	440
R9	5.85	0.023	0.004	0.534	1,380	371
R10	5.7	0.022	0.003	0.496	1,370	350
R11	5.11	0.021	0.003	0.492	1,200	343
R12	4.94	0.02	0.003	0.471	1,170	340
R13	4.9	0.02	0.003	0.467	1,110	328
R14	4.63	0.02	0.003	0.462	1,100	304
R15	4.63	0.02	0.003	0.462	1,060	296
R16	4.47	0.019	0.003	0.437	1,060	284
R17	4.36	0.018	0.003	0.428	1,030	253
R18	4.16	0.018	0.003	0.418	985	251
R19	4.1	0.018	0.003	0.41	951	246
R20	4.02	0.017	0.003	0.385	939	239
R21	3.98	0.016	0.003	0.369	922	238
R22	3.86	0.016	0.002	0.365	911	232
R23	3.62	0.015	0.002	0.352	887	223
R24	3.54	0.015	0.002	0.346	863	223
R25	3.48	0.015	0.002	0.342	854	220
R26	3.47	0.015	0.002	0.339	790	219
R27	3.24	0.013	0.002	0.29	783	217
R28	3.23	0.012	0.002	0.288	765	215
R29	3.15	0.012	0.002	0.285	764	213
R30	3.12	0.012	0.002	0.271	749	207
R31	3.04	0.012	0.002	0.269	726	200
R32	2.97	0.012	0.002	0.269	716	192
R33	2.78	0.011	0.002	0.255	684	189
R34	2.78	0.011	0.002	0.254	668	187
R35	2.78	0.01	0.002	0.243	667	186
R36	2.76	0.01	0.002	0.238	654	181
R37	2.75	0.01	0.002	0.234	654	177
R38	2.7	0.01	0.002	0.229	639	156
R39	2.57	0.01	0.002	0.225	638	155
R40	2.54	0.009	0.002	0.207	616	150
R41	2.45	0.009	0.002	0.204	607	148
R42	2.45	0.009	0.002	0.201	593	143
R43	2.44	0.008	0.001	0.197	587	140
R44	2.36	0.008	0.001	0.196	564	132
R45	2.28	0.008	0.001	0.195	526	131
R46	2.14	0.008	0.001	0.19	473	127
R47	2	0.008	0.001	0.182	473	120
R48	1.96	0.008	0.001	0.18	471	118
R49	1.95	0.007	0.001	0.171	462	117
R50	1.91	0.007	0.001	0.169	450	115
R51	1.88	0.007	0.001	0.162	448	111
R52	1.74	0.007	0.001	0.16	422	110
R53	1.73	0.006	0.001	0.149	402	107
R54	1.6	0.006	0.001	0.146	400	104
R55	1.54	0.006	0.001	0.137	376	103
R56	1.54	0.006	0.001	0.133	368	97
R57	1.5	0.006	0.001	0.129	324	96
R58	1.24	0.005	0.001	0.124	200	88

Appendix B: GLCs at receptor points for HC compounds

	Benzene	Toluene	m,p-Xylenes	N-Pentane
	1 hour	1 hour	1 hour	1 hour
EPA limit (ug/m^3)	**29**	**360**	**190**	**33,000**
Maximum GLC(ug/m^3)	**15**	**30.6**	**19.5**	**14.4**
	Concentration at each receptor in descending order			
R1	15	30.6	19.5	14.4
R2	11.25	22.95	14.625	10.8
R3	10.95	22.338	14.235	10.512
R4	9.9	20.196	12.87	9.504
R5	8.85	18.054	11.505	8.496
R6	8.8	17.952	11.44	8.448
R7	7.35	14.994	9.555	7.056
R8	7.25	14.79	9.425	6.96
R9	6.15	12.546	7.995	5.904
R10	6.1	12.444	7.93	5.856
R11	5.45	11.118	7.085	5.232
R12	5.4	11.016	7.02	5.184
R13	5.2	10.608	6.76	4.992
R14	4.97	10.1388	6.461	4.7712
R15	4.94	10.0776	6.422	4.7424
R16	4.845	9.8838	6.2985	4.6512
R17	4.725	9.639	6.1425	4.536
R18	4.6	9.384	5.98	4.416
R19	4.4	8.976	5.72	4.224
R20	4.25	8.67	5.525	4.08
R21	4.22	8.6088	5.486	4.0512
R22	4.195	8.5578	5.4535	4.0272
R23	4.075	8.313	5.2975	3.912
R24	4.03	8.2212	5.239	3.8688
R25	3.95	7.9458	5.0635	3.7392
R26	3.815	7.7826	4.9595	3.6624
R27	3.61	7.3644	4.693	3.4656
R28	3.535	7.2114	4.5955	3.3936
R29	3.45	7.038	4.485	3.312
R30	3.415	6.9666	4.4395	3.2784
R31	3.345	6.8238	4.3485	3.2112
R32	3.27	6.6708	4.251	3.1392
R33	3.27	6.6708	4.251	3.1392
R34	3.09	6.3036	4.017	2.9664
R35	3.065	6.2526	3.9845	2.9424
R36	2.985	6.0894	3.8805	2.8656
R37	2.925	5.967	3.8025	2.808
R38	2.925	5.967	3.8025	2.808
R39	2.92	5.9568	3.796	2.8032
R40	2.86	5.8344	3.718	2.7456
R41	2.795	5.7018	3.6335	2.6832
R42	2.715	5.5386	3.5295	2.6064
R43	2.715	5.5386	3.5295	2.6064
R44	2.625	5.355	3.4125	2.52
R45	2.525	5.151	3.2825	2.424
R46	2.38	4.8552	3.094	2.2848
R47	2.13	4.3452	2.769	2.0448
R48	2.125	4.335	2.7625	2.04
R49	2.115	4.3146	2.7495	2.0304
R50	2.07	4.2228	2.691	1.9872
R51	2.045	4.1718	2.6585	1.9632
R52	2.02	4.1208	2.626	1.9392
R53	1.9	3.876	2.47	1.824
R54	1.84	3.7536	2.392	1.7664
R55	1.83	3.7332	2.379	1.7568
R56	1.695	3.4578	2.2035	1.6272
R57	1.65	3.366	2.145	1.584
R58	1.485	3.0294	1.9305	1.4256