BEFORE THE ENVIRONMENT COURT
AT AUCKLAND

ENV-2020-AKL-000064

I MUA I TE KOOTI TAIAO O AOTEAROA
TĀMAKI MAKAURAU ROHE

IN THE MATTER	of an appeal under the first schedule of the Resource Management Act 1991 (**RMA**)
BETWEEN	**AWATARARIKI RESIDENTS INCORPORATED**
	Appellant
AND	**BAY OF PLENTY REGIONAL COUNCIL**
	First Respondent
AND	**WHAKĀTANE DISTRICT COUNCIL**
	Second Respondent and Requestor of Plan Change 17

AFFIDAVIT OF PETER LINDSAY BLACKWOOD

ENGINEERING – METEOROLOGY

23 November 2020

BROOKFIELDS
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I, Peter Lindsay Blackwood, meteorologist of Whakatāne, swear:

1. INTRODUCTION

1.1. My full name is Peter Lindsay Blackwood.

1.2. I gave evidence at the Commissioner hearing which resulted in the decisions on Plan Changes 1 and 17, which in turn are the subject of this appeal.

1.3. I confirm that I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Consolidated Practice Note 2014. I agree to comply with the Code when presenting evidence to the Court. I confirm that the issues addressed in this brief of evidence are within my area of expertise, except where I state that I rely upon the evidence of another expert witness. I also confirm that I have not omitted to consider material facts known to me that might alter or detract from the opinions.

1.4. This affidavit addresses:

(a) My qualifications and experience

(b) The frequency with which MetService Heavy Rain and Thunderstorm weather warning criteria are likely to be met in the year of March 2021 to March 2022.

2. QUALIFICATIONS AND EXPERIENCE

2.1. I hold the position of Principal Technical Engineer at Bay of Plenty Regional Council (**Regional Council**).

2.2. My qualifications include a Bachelor of Engineering (Civil) with Honours degree from Canterbury University.

2.3. I was awarded the IPENZ National Arch Campbell Award for river and catchment engineering in 2015.

2.4. I have 44 years' experience in central and regional government environmental and civil engineering. My areas of specialist advice include:

(a) Flood and rainfall frequency including detailed assessment of the extreme value frequency distributions and impacts of climatic trends such as the Interdecadal Pacific Oscillation (IPO). This

includes research into and co-authoring of specialist computer programmes FRAN and FRANCES for the former Ministry of Works. These assessed up to seven different frequency distributions applied to continuous series and censored data.

(b) Climate change policy and design;

(c) River and stream hydraulics;

(d) Design of river protection works;

(e) River and catchment engineering; and

(f) Coastal engineering including impacts of storm surge on coastal inundation

2.5. Between 2006 and 2016 I was employed as Manager Design, Manawatu-Whanganui Regional Council, principally to manage the design of a multimillion dollar flood protection works upgrade on the Manawatu, Oroua, Rangitikei and Pohangina Rivers and Mākino Stream and Floodway following the very large 2004 so-called "Manawatu Floods". I also designed the upgrade of stopbanks in Whanganui, including the major Balgownie Industrial Area stopbank

2.6. I was previously employed by the Regional Council (then known as Environment Bay of Plenty) as Technical Services Manager between 1996 and 2006.

3. METSERVICE HEAVY RAIN AND THUNDERSTORM WEATHER WARNING CRITERIA FREQUENCY ANALYSIS

3.1. I have undertaken a meteorological analysis to determine the frequency with which the following MetService severe weather warning rainfall criteria will be met at Matatā:

(a) Heavy Rain:

i. Widespread (broad-scale) impacts over an area of at least 1000km2 and more than 50mm in six hours: or

ii. More than 100mm in 24 hours.

(b) Thunderstorm:

i. Affects a localised area (small-scale) for a short period of time with rain of 25mm/h or more.

3.2. The rainfall frequencies were determined by reference to the nearest rainfall gauges at both Tarawera at Awakaponga and Ohinekoao at Harris Saddle. The analysis was based on the High Intensity Rainfall Design System (HIRDS) Version 4 data with climate change from the baseline year of 1980 to the year 2021 added. The recorded number of events exceeding the MetService thresholds for both these sites over the period of the data record was analysed. Please refer to location map below.

Figure One: Location of Rainfall Gauges

3.3. The full data analysis is included as exhibits:

(a) Tarawera at Awakaponga marked as exhibit A;

(b) Ohinekoao at Harris Saddle marked as exhibit B.

3.4. The analysis has found that the rainfall criteria in the MetService Severe Weather Warning and Severe Thunderstorm warning will occur

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moderately frequently. The frequencies and return periods are as in the following table. Note the longer duration rainfalls are higher at Ohinekoao:

Location	Duration (hrs)	Threshold (mm)	AEP	Return Period (Yrs)
Tarawera at Awakaponga	1	25	0.895	1.11
	6	50	0.896	1.12
	24	100	0.527	1.90
Ohinekoao at Harris Saddle	1	25	0.900	1.11
	6	50	0.996	1.004
	24	100	0.979	1.021

3.5. The below table presents the number of recorded rainfall events where the rainfall thresholds have been exceeded.

Location	Duration (hrs)	Threshold (mm)	Number of Events Exceeding Threshold
Tarawera at Awakaponga (1990 – 2018)	1	25	44
	6	50	50
	24	100	31
Ohinekoao at Harris Saddle (2001-2018)	1	25	30
	6	50	60
	24	100	48

3.6. An examination of the nominated period from 1 November 2018 to 30 October 2020 shows the following information on the number of recorded rainfall events where the rainfall thresholds have been exceeded:

(a) At the Tarawera at Awakaponga gauge, one occasion when both the 6 hour and 24 hour thresholds would have both been exceeded in the same rainfall event and no occasions when the 1 hour duration would have been exceeded.

(b) At the Ohinekoao at Harris Saddle gauge, three occasions when either the 6 hour or 24 hour, or both, thresholds would have been exceeded in the same rainfall event and no occasions when the 1 hour duration would have been exceeded

3.7. However, this is not reflective of the long term trend, where the frequency of events exceeding the threshold has been higher. To examine this I have looked in depth at the full period of recorded data on both rain gauges to

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determine the number of separate events where one or more of the thresholds would have been exceeded. If, during an event, more than one of the thresholds were exceeded (1, 6 and/or 24 hours) it is scored as one occurrence, as the evacuation would of course only occur once. Similarly, I have discounted cases where a repeat of a threshold exceedance has occurred within 24 hours of the first exceedance, as the property is unlikely to be re-inhabited in that period. My analysis yielded the following information:

(a) At the Tarawera at Awakaponga gauge, 74 occasions in 31 years, being an average of 2.39 times per year, with the annual totals varying between 0 and 6 times.

(b) At the Ohinekoao at Harris Saddle gauge, 75 occasions in 20 years, being an average of 3.75 times per year, with the annual totals varying between 1 and 10 times – note the second highest total was 7 events.

3.8. The most likely explanation for the previous higher frequency of rainstorms that exceed the threshold values, is changes in the Interdecadal Pacific Oscillation (IPO). This is a climatic trend that quite strongly affects flooding in the eastern Bay of Plenty. It shifted to a more active period in 1998 and possibly has entered a more quiescent period in recent years. I have considered this possibility as more likely, than not. However, I must stress that nothing is certain with nature.

3.9. In evaluating the available data to form a view on the number of exceedances likely during the year of March 2021 to March 2022, I have taken one standard deviation from the mean and made a further reduction to reflect a fairly certain quiescent trend in the latter years which is reflected in the data.

3.10. Consequently, after evaluating all the data available, my best estimate of the number of times the MetService rainfall threshold criteria for Severe Weather Warnings are likely to be exceeded between 15 December 2020 and 31 March 2022 is between 1 and 5 times.

4.0 CONCLUSION

4.1 The analyses of historic rainfall records from two BOPRC rain gauges in close proximity to the Awatarariki catchment over the past 24 years indicate that MetService rainfall threshold criteria for Severe Weather Warnings are highly likely to be exceeded between 15 December 2020 and 31 March 2022.

4.2 Although there is a high degree of uncertainty in predicting future rainfall event recurrence intervals, based on the historic rainfall patterns referred to above, and including a climate change component, my best estimate of the number of times the MetService rainfall threshold criteria for Severe Weather Warnings are likely to be exceeded between 15 December 2020 and 31 March 2022 is between 1 and 5 times.

SWORN at)
this day of)
2020 before me:)

P.L. Blackwood

(Peter Lindsay Blackwood)

Saraya Ricky Waihoroi Ngatai

A Solicitor of the High Court of New Zealand

Exhibit A: Tarawera at Awakaponga Rainfall Data

HIRDS V4 Depth-Duration-Frequency Results
Sitename: Tarawera at Awakaponga
Coordinate system: WGS84
Longitude: 176.7672
Latitude: -37.9408

DDF Mode Parameter	c	d	e	f	g	h	i
Values:	-0.00302	0.455716	-0.03541	0	0.270438	-0.00992	3.40414

Example:	Duration (h	ARI (yrs)	x	y	Rainfall Depth (mm)
	24	100	3.178054	4.600149	240.9987

Rainfall depths (mm) :: Historical Data

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	11.9	17.5	21.6	30.1	40.5	60.7	75	89.5	103	110	115	118
2	0.5	13.1	19.3	23.8	33.2	44.7	66.9	82.5	98.4	113	121	126	130
5	0.2	17.6	25.8	31.7	44.1	59.3	88.4	109	130	149	159	166	170
10	0.1	21	30.8	37.9	52.6	70.6	105	129	153	176	188	195	200
20	0.05	24.7	36.1	44.4	61.6	82.5	122	150	178	204	218	226	232
30	0.033	26.9	39.4	48.4	67.1	89.8	133	163	193	221	236	245	251
40	0.025	28.6	41.8	51.4	71.1	95.2	141	173	204	234	249	259	265
50	0.02	29.9	43.7	53.7	74.3	99.4	147	180	213	244	260	270	276
60	0.017	31	45.3	55.7	77	103	152	186	220	252	268	279	286
80	0.012	32.8	47.9	58.8	81.3	109	160	196	232	265	282	293	300
100	0.01	34.2	49.9	61.3	84.6	113	167	204	241	275	293	304	312
250	0.004	40.2	58.5	71.8	99	132	194	237	279	318	339	351	360

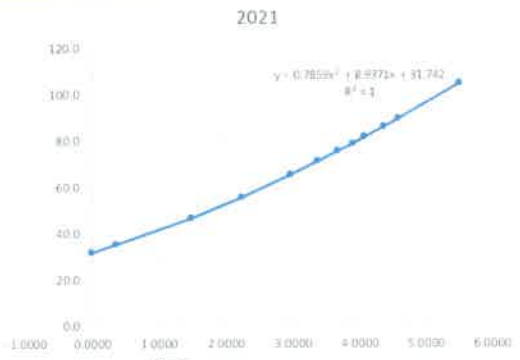
Depth standard error (mm) :: Historical Data

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	0.76	1.1	1.9	1.6	2	5.3	10	5.1	3	6.7	6.8	11
2	0.5	0.81	1.1	2.1	1.7	2.1	5.8	11	5.6	3.1	7.4	7.4	12
5	0.2	1.3	2	3.2	3.2	3.8	8.2	16	8.5	5.7	11	11	17
10	0.1	2	3.1	4.5	5.2	6.2	11	20	12	8.9	14	14	21
20	0.05	2.9	4.5	6.2	8	9.6	15	25	16	13	18	19	26
30	0.033	3.5	5.5	7.4	10	12	18	28	19	16	21	22	30
40	0.025	4.1	6.4	8.4	12	14	20	32	21	18	24	25	33
50	0.02	4.5	7.1	9.2	14	16	22	34	23	20	26	28	35
60	0.017	4.9	7.7	10	15	18	24	37	25	22	27	30	37
80	0.012	5.6	8.8	11	17	21	27	41	28	25	31	33	41
100	0.01	6.1	9.8	12	20	23	30	44	30	28	33	36	44
250	0.004	9	14	18	31	36	45	62	43	40	46	51	59

Tarawera at Awakaponga: One Year Climate Change to 2021 0.43 degrees - 1 hour rainfall

ARI	AEP	Y	Base	2021	Check
1.58	0.633	-0.0021	30.1	31.9	31.9
2	0.5	0.3665	33.2	35.1	35.1
5	0.2	1.4999	44.1	46.7	46.7
10	0.1	2.2504	52.6	55.7	55.7
20	0.05	2.9702	61.6	65.2	65.2
30	0.033	3.3843	67.1	71.0	71.0
40	0.025	3.6762	71.1	75.3	75.3
50	0.02	3.9019	74.3	78.6	78.6
60	0.017	4.0860	77	81.5	81.5
80	0.012	4.3757	81.3	86.1	86.1
100	0.01	4.6001	84.6	89.5	89.5
250	0.004	5.5195	99	104.8	104.8

Climate Change (degrees)		0.4300	2021	
Duration			1 hour	
Mulitplier		1.0585	HIRDS V4 Table 5	
	-0.5000			27.47
1.117375	-0.8124			25.00
1.117375 0.894955	-0.8124			

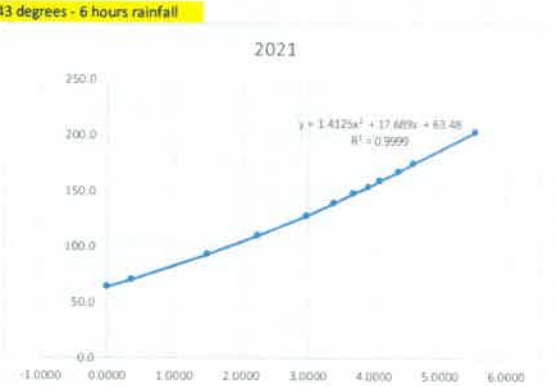


This is a true copy of the exhibit marked with the letter "A" referred to in the annexed affidavit of **PETER LINDSAY BLACKWOOD** sworn at this 23rd day of November 2020 before me:

Solicitor of the High Court of New Zealand / Justice of the Peace

Tarawera at Awakaponga: One Year Climate Change to 2021 0.43 degrees - 6 hours rainfall

ARI	AEP	Y	Base	2021	Check
1.58	0.633	-0.0021	60.7	63.7	63.7
2	0.5	0.3665	66.9	70.2	70.2
5	0.2	1.4999	88.4	92.8	92.8
10	0.1	2.2504	105	110.2	110.2
20	0.05	2.9702	122	128.0	128.0
30	0.033	3.3843	133	139.6	139.6
40	0.025	3.6762	141	148.0	148.0
50	0.02	3.9019	147	154.3	154.3
60	0.017	4.0860	152	159.5	159.5
80	0.012	4.3757	160	167.9	167.9
100	0.01	4.6001	167	175.3	175.3
250	0.004	5.5195	194	203.6	203.6
Climate Change (degrees)			0.4300	2021	
Duration				6 hour	
Mulitplier			1.0495	HIRDS V4 Table 5	
		-0.5000			
1.116583		-0.8151			
1.116583	0.895589	-0.8151			



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Tarawera at Awakaponga: One Year Climate Change to 2021 0.43 degrees - 24 hours rainfall

ARI	AEP	Y	Base	2021	Check
1.58	0.633	-0.0021	89.5	92.8	92.8
2	0.5	0.3665	98.4	102.0	102.0
5	0.2	1.4999	130	134.8	134.8
10	0.1	2.2504	153	158.7	158.7
20	0.05	2.9702	178	184.6	184.6
30	0.033	3.3843	193	200.1	200.1
40	0.025	3.6762	204	211.5	211.5
50	0.02	3.9019	213	220.9	220.9
60	0.017	4.0860	220	228.1	228.1
80	0.012	4.3757	232	240.6	240.6
100	0.01	4.6001	241	249.9	249.9
250	0.004	5.5195	279	289.3	289.3
Climate Change (degrees)			0.4300	2021	
Duration				24 hour	
Mulitplier			1.0370	HIRDS V4 Table 5	
		-0.5000			
1.895897		0.2882			
1.895897	0.527455	0.2882			

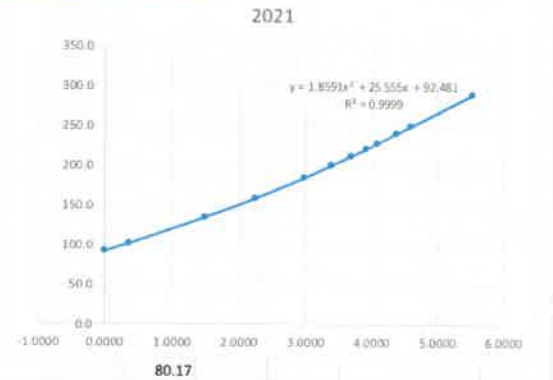

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Exhibit B: Ohinekoao at Harris Saddle Rainfall Data

HIRDS V4 Depth-Duration-Frequency Results
Sitename: Ohinekoao at Harris Saddle
Site ID: 769705
Coordinate system: NZGD1949
Longitude: 176.7085
Latitude: -37.9085

DDF Mode Parameter	c	d	e	f	g	h	i
Values:	-0.00266	0.601126	-0.01257	-0.00632	0.262197	-0.01005	3.410201

Example:	Duration (hr)	ARI (yrs)	x	y	Rainfall Depth (mm)
	24	100	3.178054	4.600149	381.9482

Rainfall depths (mm) :: Historical Data

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	10.3	15.5	19.9	30.3	45.5	82.3	113	147	178	192	198	201
2	0.5	11.3	17.1	21.9	33.3	50	90.3	124	161	195	210	217	221
5	0.2	15	22.6	28.9	43.9	65.8	118	162	210	254	273	282	286
10	0.1	17.8	26.8	34.2	51.9	77.8	140	191	247	298	321	331	336
20	0.05	20.8	31.2	39.9	60.4	90.3	162	221	286	344	370	382	387
30	0.033	22.6	34	43.3	65.5	98	175	240	309	372	400	412	418
40	0.025	23.9	35.9	45.8	69.3	104	185	253	326	392	421	435	440
50	0.02	25	37.5	47.8	72.3	108	193	263	340	408	438	452	458
60	0.017	25.8	38.8	49.4	74.7	112	199	272	351	421	452	466	472
80	0.012	27.2	40.9	52.1	78.7	117	209	286	368	442	474	489	495
100	0.01	28.3	42.5	54.1	81.8	122	217	297	382	459	492	507	513
250	0.004	33	49.4	62.9	94.8	141	251	342	439	527	564	581	588

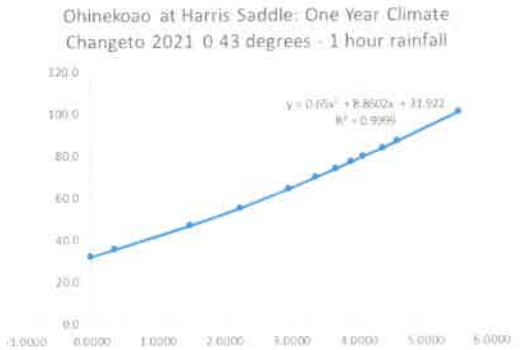
Depth standard error (mm) :: Historical Data

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	0.97	1.4	1.7	2.6	3.5	7.1	9.3	13	15	18	18	18
2	0.5	1	1.5	1.8	2.8	3.9	7.7	10	15	17	19	20	20
5	0.2	1.6	2.3	2.7	4.1	5.9	11	15	20	23	27	27	27
10	0.1	2.2	3.2	3.8	5.6	8.1	15	20	25	29	34	33	34
20	0.05	3	4.4	5.3	7.7	11	20	27	31	36	43	41	42
30	0.033	3.6	5.3	6.3	9.4	14	24	33	35	41	49	47	48
40	0.025	4	6	7.2	11	16	27	37	38	45	53	51	53
50	0.02	4.5	6.6	8	12	18	30	41	41	48	57	55	57
60	0.017	4.8	7.2	8.6	13	19	32	45	43	51	61	58	60
80	0.012	5.4	8.1	9.8	15	22	37	51	47	56	67	63	66
100	0.01	6	8.9	11	16	24	40	56	51	60	72	68	71
250	0.004	8.6	13	16	25	37	60	83	67	80	95	90	95

Ohinekoao at Harris Saddle: One Year Climate Change to 2021 0.43 degrees - 1 hour rainfall

ARI	AEP	Y	Base	2021	Check
1.58	0.633	-0.0021	30.3	32.1	32.1
2	0.5	0.3665	33.3	35.2	35.2
5	0.2	1.4999	43.9	46.5	46.5
10	0.1	2.2504	51.9	54.9	54.9
20	0.05	2.9702	60.4	63.9	63.9
30	0.033	3.3843	65.5	69.3	69.3
40	0.025	3.6762	69.3	73.4	73.4
50	0.02	3.9019	72.3	76.5	76.5
60	0.017	4.0860	74.7	79.1	79.1
80	0.012	4.3757	78.7	83.3	83.3
100	0.01	4.6001	81.8	86.6	86.6
250	0.004	5.5195	94.8	100.3	100.3

Climate Change (degrees)			0.4300	2021
Duration				1 hour
Mulitplier			1.0585	HIRDS V4 Table 5
		-0.5000		
1.11168		-0.8320		
1.11168	0.899539	-0.8320		



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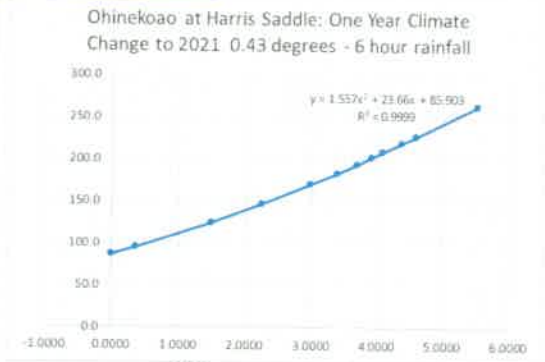
This is a true copy of the exhibit marked with the letter "B" referred to in the annexed affidavit of PETER LINDSAY BLACKWOOD sworn at this 3rd day of November 2020 before me:

Solicitor of the High Court of New Zealand / Justice of the Peace

Ohinekoao at Harris Saddle: One Year Climate Change to 2021 0.43 degrees - 6 hour rainfall

ARI	AEP	Y	Base	2021	Check
1.58	0.633	-0.0021	82.3	86.4	86.4
2	0.5	0.3665	90.3	94.8	94.8
5	0.2	1.4999	118	123.8	123.8
10	0.1	2.2504	140	146.9	146.9
20	0.05	2.9702	162	170.0	170.0
30	0.033	3.3843	175	183.7	183.7
40	0.025	3.6762	185	194.1	194.1
50	0.02	3.9019	193	202.5	202.5
60	0.017	4.0860	199	208.8	208.8
80	0.012	4.3757	209	219.3	219.3
100	0.01	4.6001	217	227.7	227.7
250	0.004	5.5195	251	263.4	263.4

Climate Change (degrees)			0.4300	2021
Duration				1 hour
Mulitplier			1.0495	HIRDS V4 Table 5
		-0.5000		
1.003989		-1.7098		
1.003989	0.996027	-1.7098		



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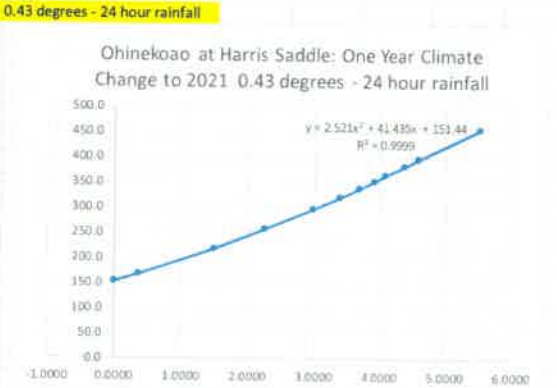
Ohinekoao at Harris Saddle: One Year Climate Change to 2021 0.43 degrees - 24 hour rainfall

ARI	AEP	Y	Base	2021	Check
1.58	0.633	-0.0021	147	152.4	152.4
2	0.5	0.3665	161	167.0	167.0
5	0.2	1.4999	210	217.8	217.8
10	0.1	2.2504	247	256.1	256.1
20	0.05	2.9702	286	296.6	296.6
30	0.033	3.3843	309	320.4	320.4
40	0.025	3.6762	326	338.1	338.1
50	0.02	3.9019	340	352.6	352.6
60	0.017	4.0860	351	364.0	364.0
80	0.012	4.3757	368	381.6	381.6
100	0.01	4.6001	382	396.1	396.1
250	0.004	5.5195	439	455.2	455.2

Climate Change (degrees)			0.4300	2021
Duration				1 hour
Mulitplier			1.0370	HIRDS V4 Table 5
		-0.5000		
1.02134		-1.3528		
1.02134	0.979106	-1.3528		



131.35
100.00