Modelling Group
WATER NEW ZEALAND

Modelling Symposium

Climate change: moving the target for wastewater overflows

Presented by
Manu Ward, Hydraulic Analysis Ltd
with Trevor Carey-Smith, NIWA

HAL HYDRAULIC ANALYSIS LIMITED

water NEW ZEALAND
The New Zealand Water & Wastes Association Waiora Aotearoa

Moving the target for wastewater overflows

- Key question: how should we assess wastewater performance under future climate conditions?
- Background:
  - wastewater network performance
  - climate change and “long time series” rainfall
- How to “move the target”?
- Problems with HIRDS (annual maxima)
- Reworking with monthly maxima (for sub-annual ARIs)
- Resulting tables

Cyclone Gabrielle approaches Wellington (Stuff / Bruce Mackay)

Wastewater network performance

- Four categories of common issues…

Combined stormwater and wastewater overflow into Meola Creek (NZ Geographic / Arno Gasteiger)

Capacity

Wet Weather Overflows

Intermittent discharges of diluted wastewater to land or water. These usually occur during intense wet weather periods because of capacity constraints during normal network operation, not as a result of blockage.

Dry Weather Overflows

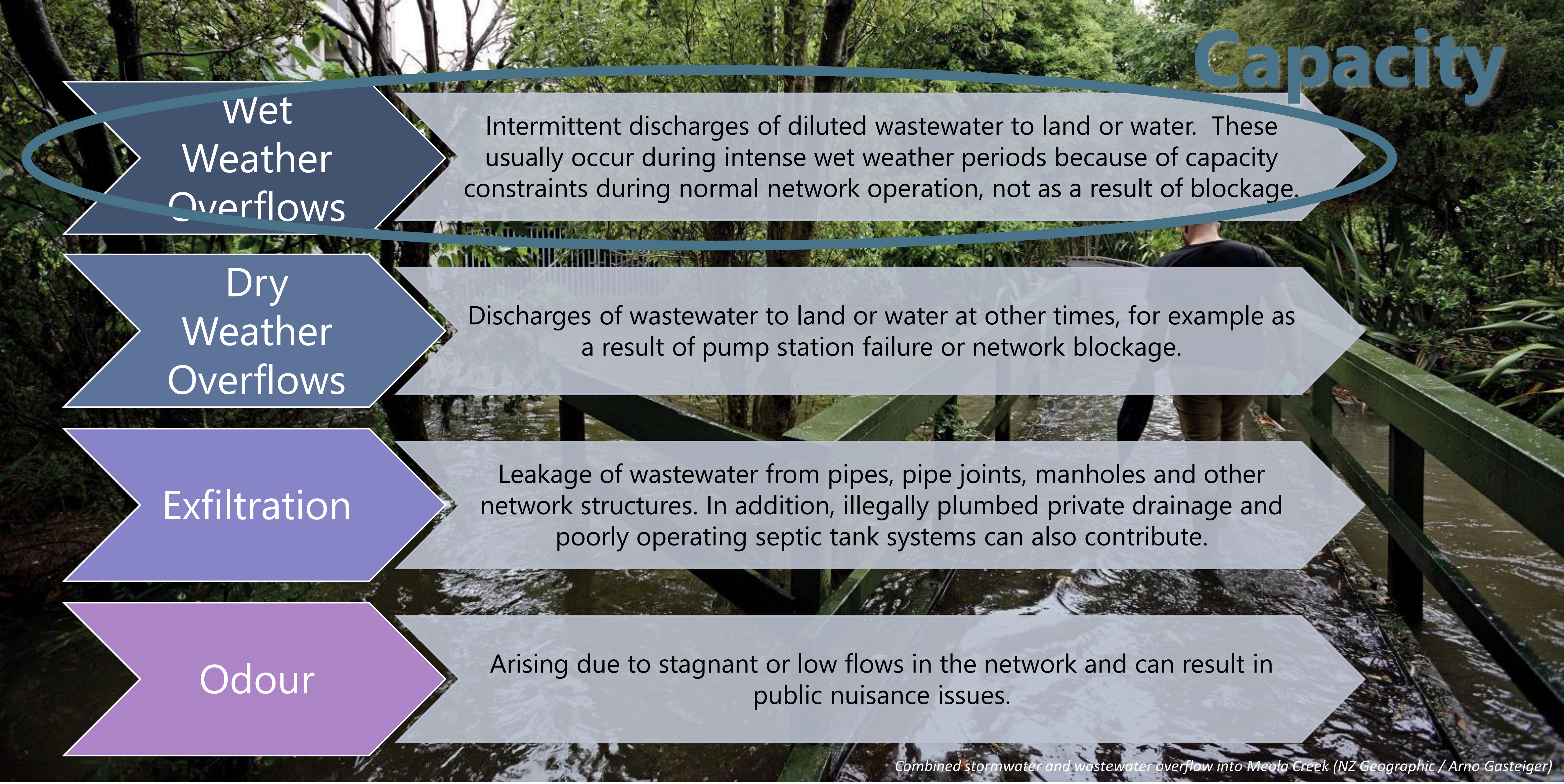
Discharges of wastewater to land or water at other times, for example as a result of pump station failure or network blockage.

Exfiltration

Leakage of wastewater from pipes, pipe joints, manholes and other network structures. In addition, illegally plumbed private drainage and poorly operating septic tank systems can also contribute.

Odour

Arising due to stagnant or low flows in the network and can result in public nuisance issues.



Combined stormwater and wastewater overflow into Meola Creek (NZ Geographic / Arno Gasteiger)

Types of wet weather overflow

- Controlled overflow points

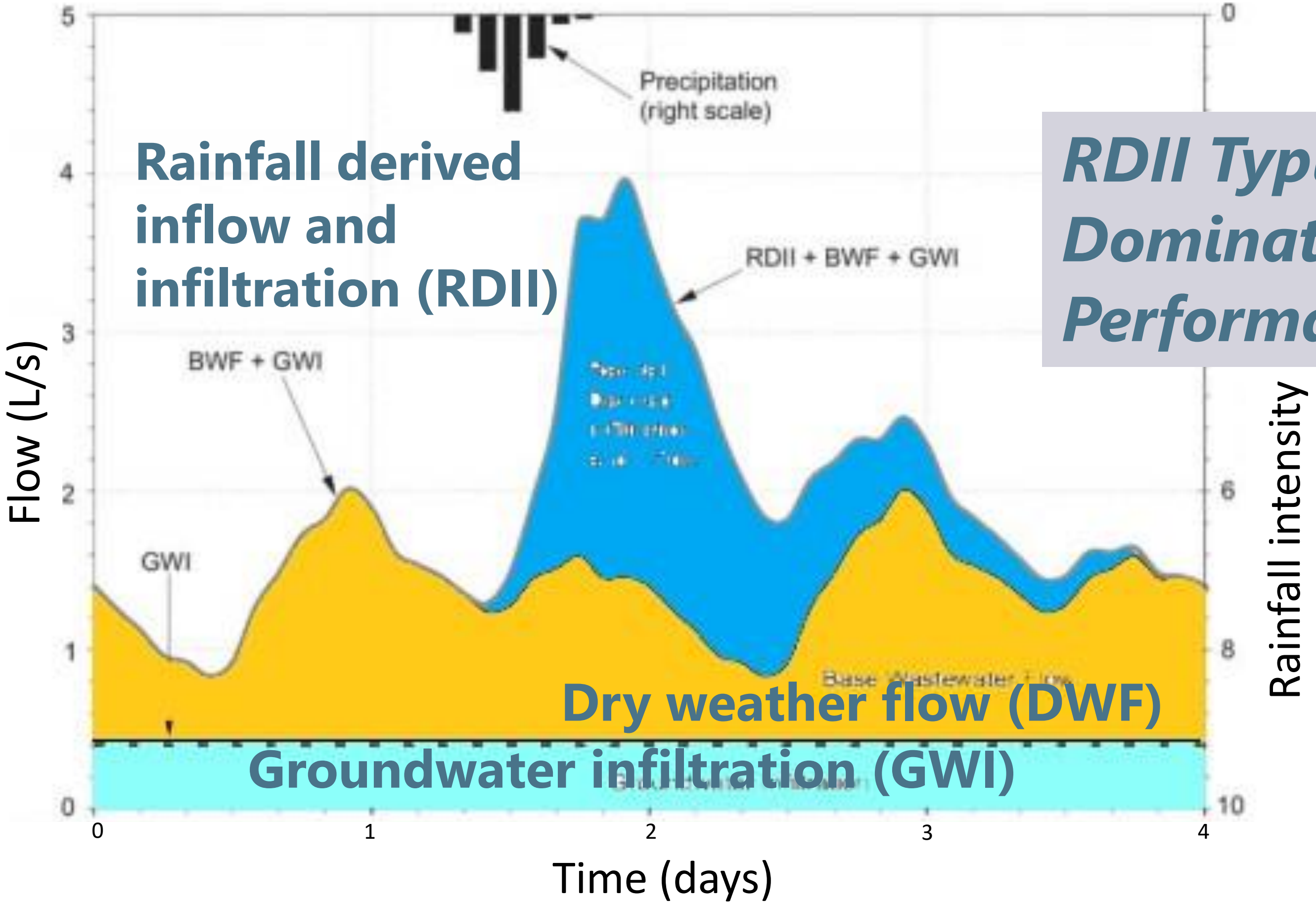
PS36 Island bay

PS38 Owhiro Bay

Types of wet weather overflow

- Controlled overflow points
- Uncontrolled overflows

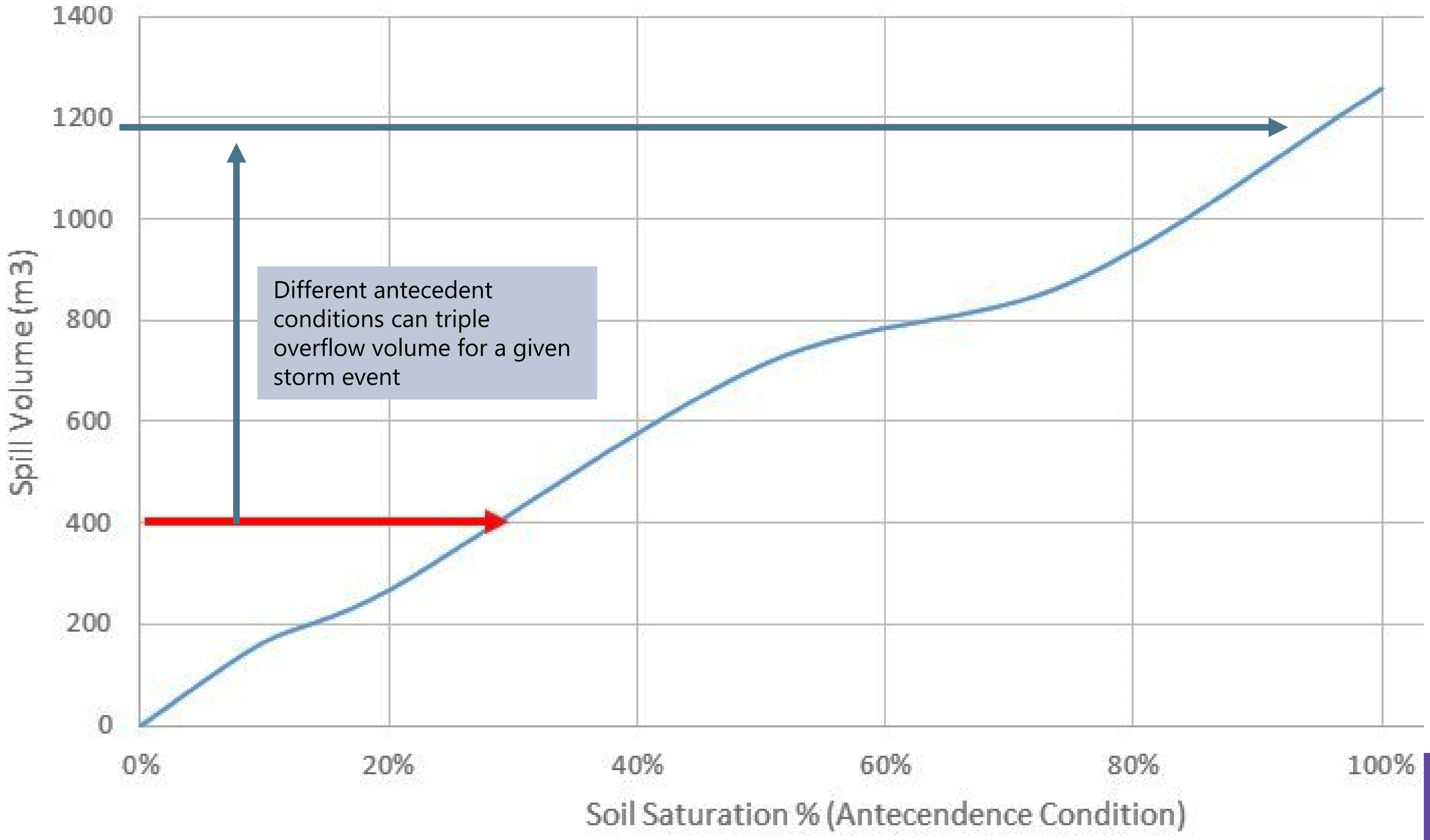
Sources of wastewater



RDII Typically Dominates Sewer Performance

Adapted from Walski, et.al., 2007

Design storms



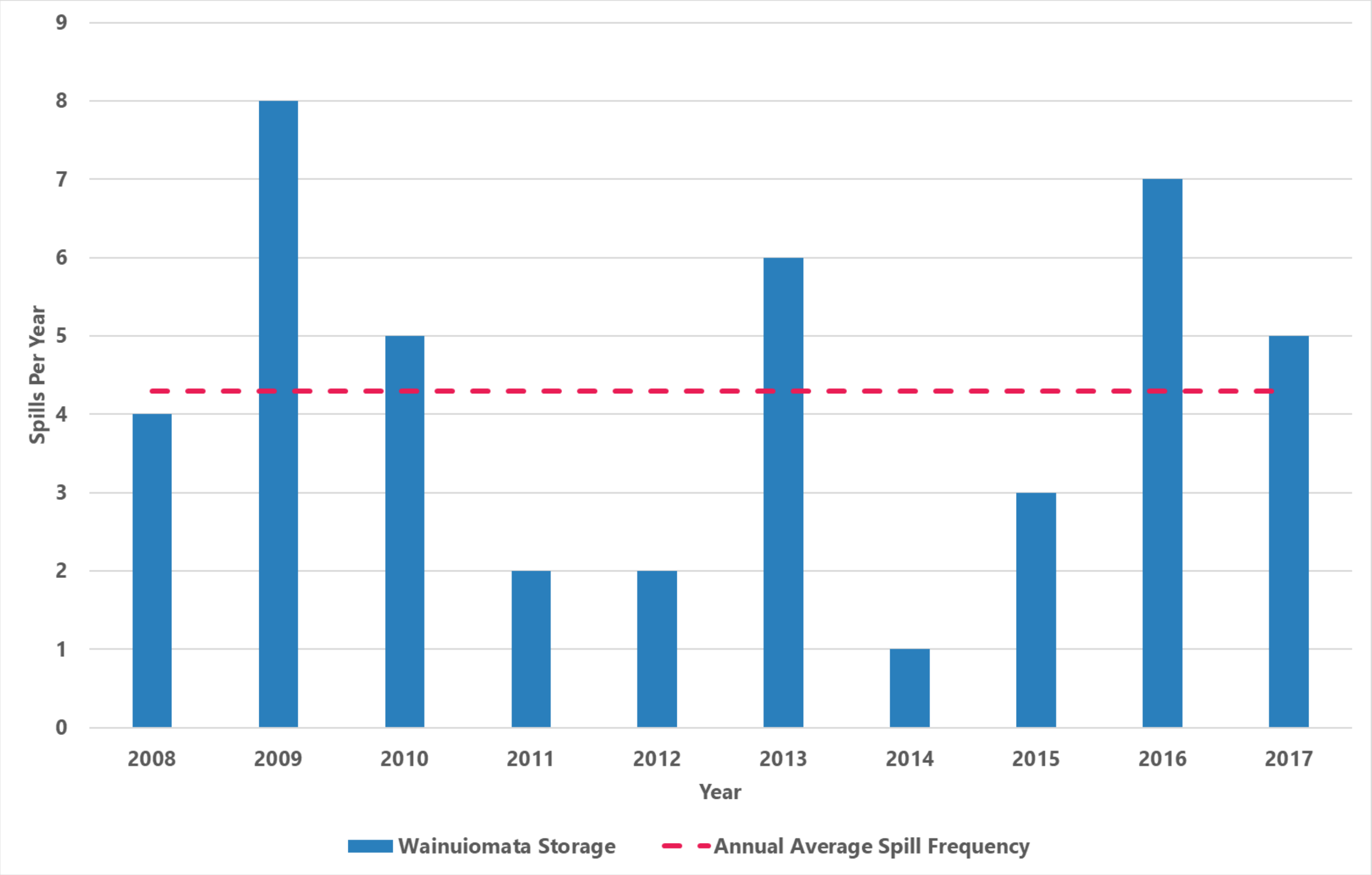
Design storms useful for debugging models.

Rainfall ARI is not related to overflow ARI.

Antecedent conditions impact performance.

Design storms not used for reporting performance targets

Overflow performance



Spills frequency varies with rainfall.

To estimate average spill frequency, need a length of record 6x ARI.

A well-calibrated model is the most reliable way to assess average performance.

Overflow performance

LEGEND

Engineered Overflow Point

Spills per Year

- <= 0.5 (2-yr ARI LoS compliant)
- 0.5 - 1 (1-yr ARI LoS compliant)
- 1 - 2 (6-mnth ARI LoS compliant)
- 2 - 6 (2-mnth ARI LoS compliant)
- 6 - 12
- > 12
- No simulated spills

Volume Class

Low Med Large

Uncontrolled Overflow

Spills per Year

- <= 0.5 (2-yr ARI LoS compliant)
- 0.5 - 1 (1-yr ARI LoS compliant)
- 1 - 2 (6-mnth ARI LoS compliant)
- 2 - 6 (2-mnth ARI LoS compliant)
- 6 - 12
- > 12

Volume Class

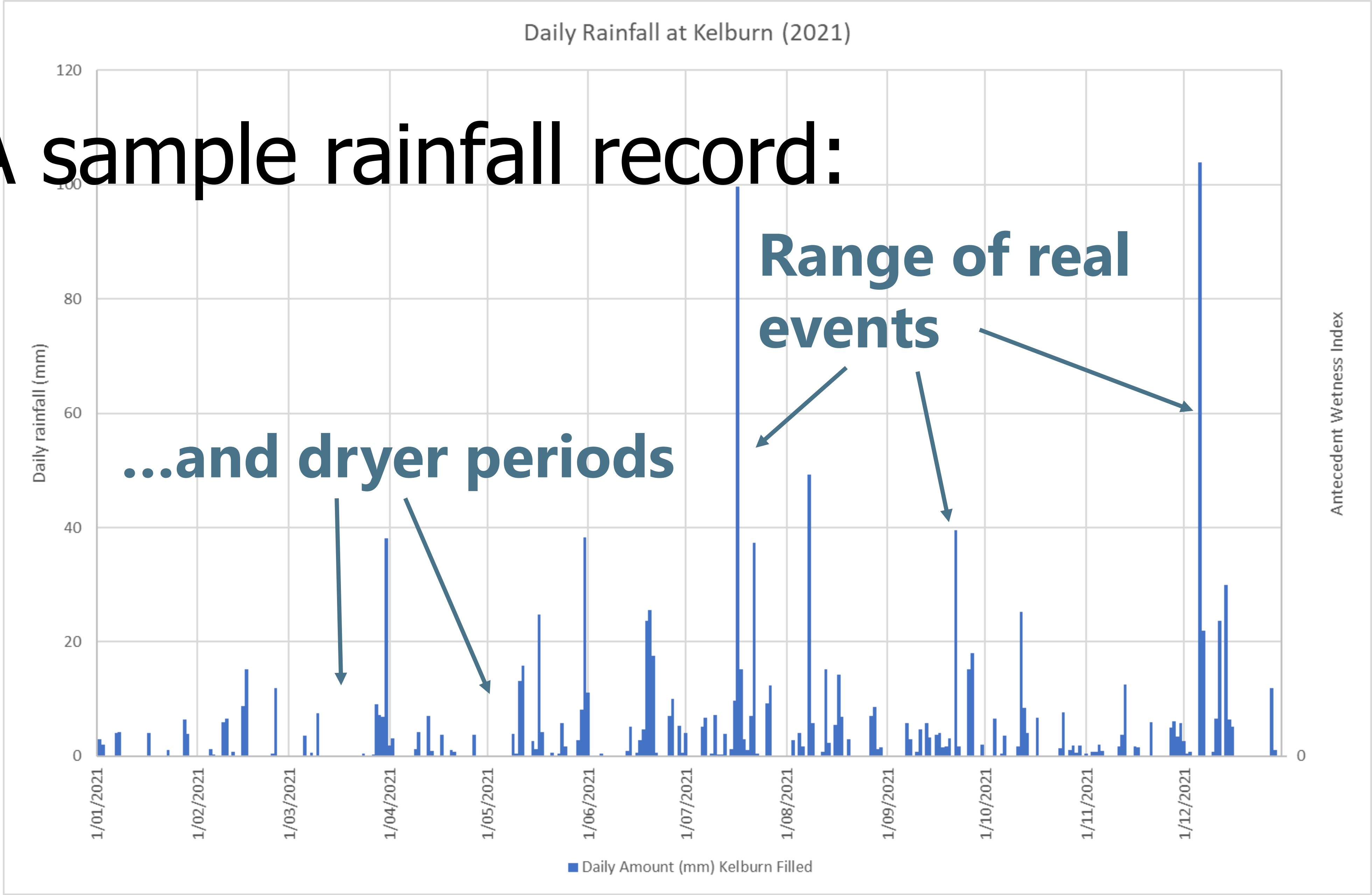
Low Med Large

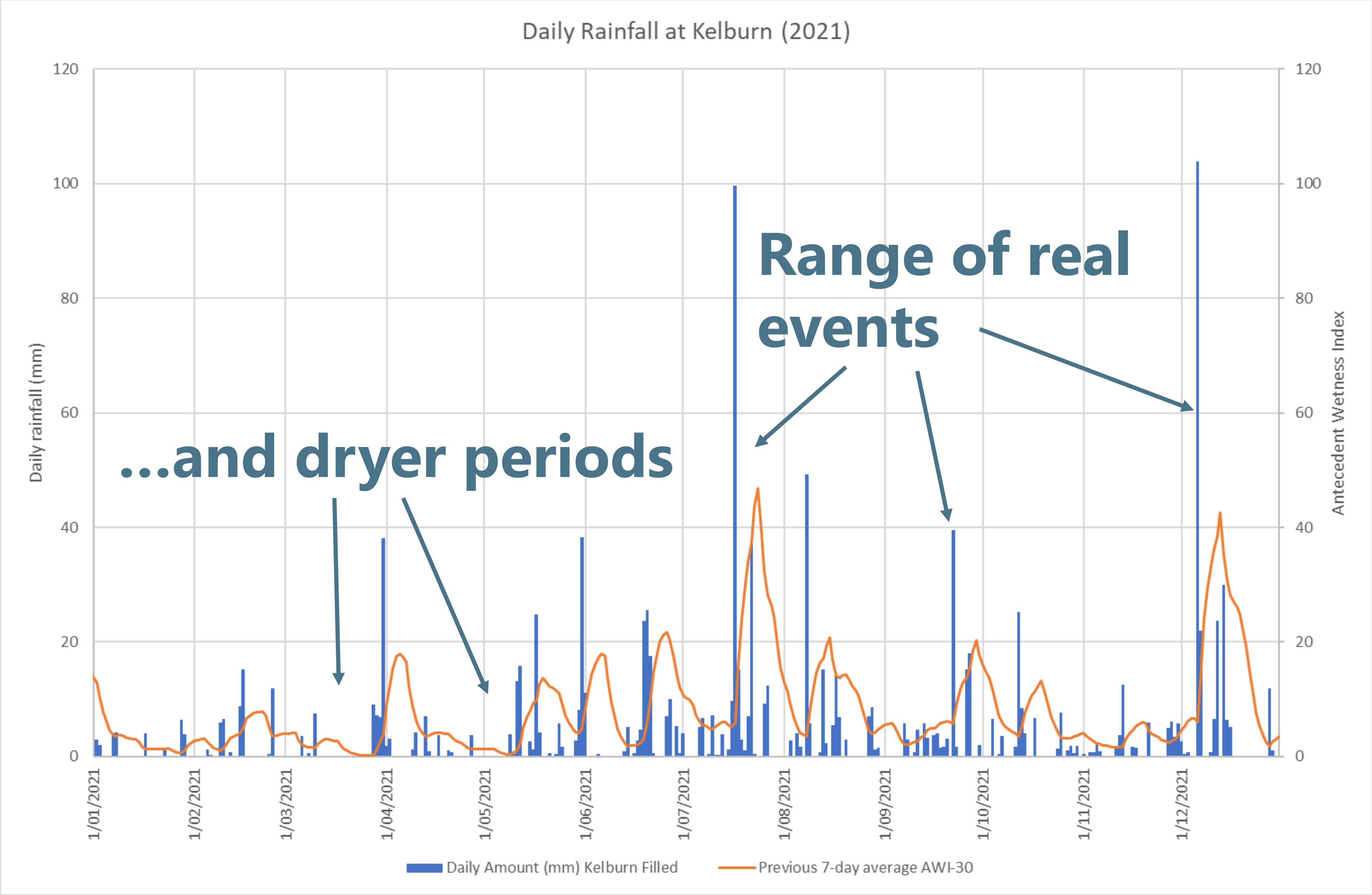
Overflow performance

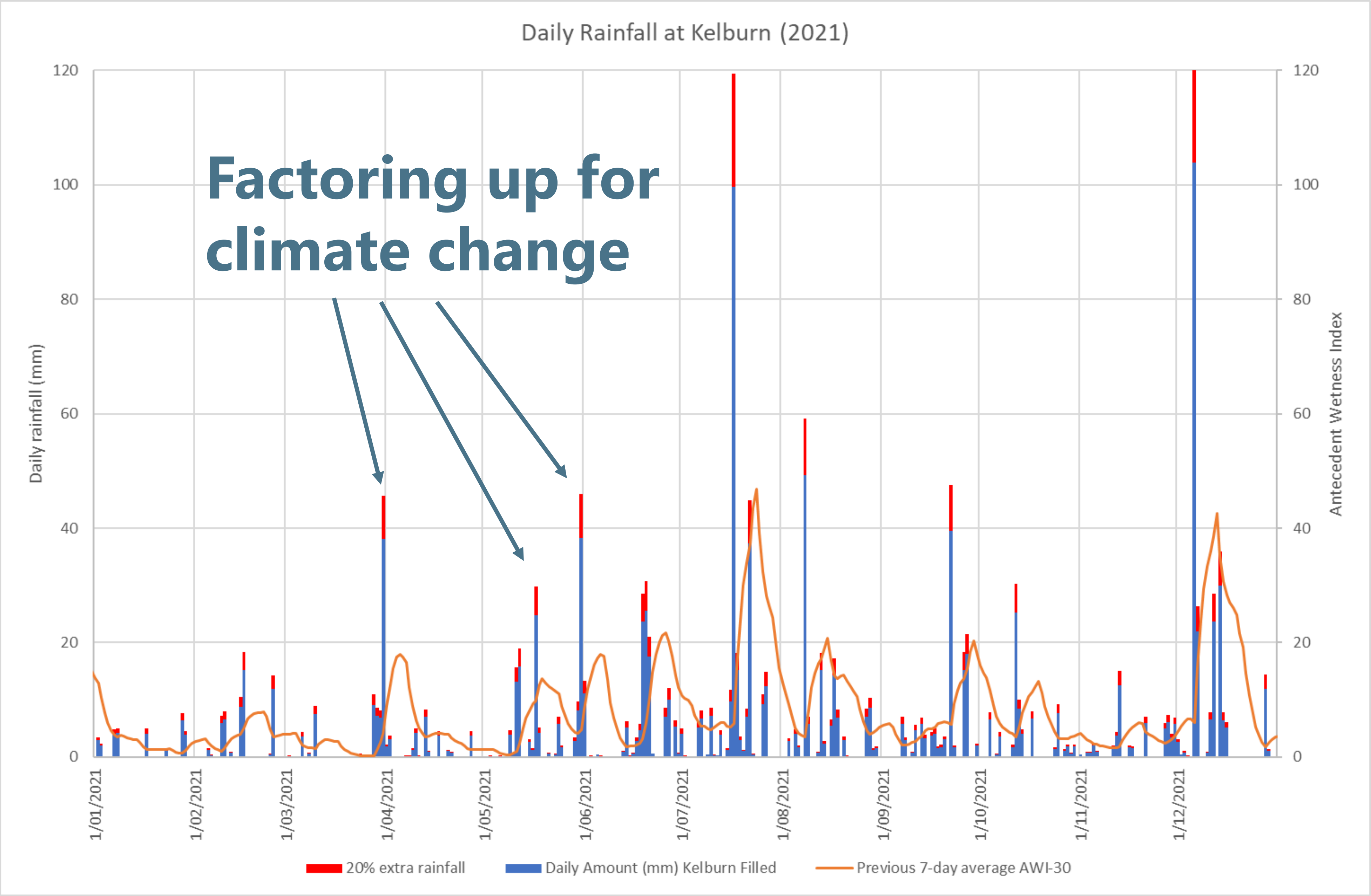
Future performance a function of

- Population growth
- Network changes in RDII
- Climate change

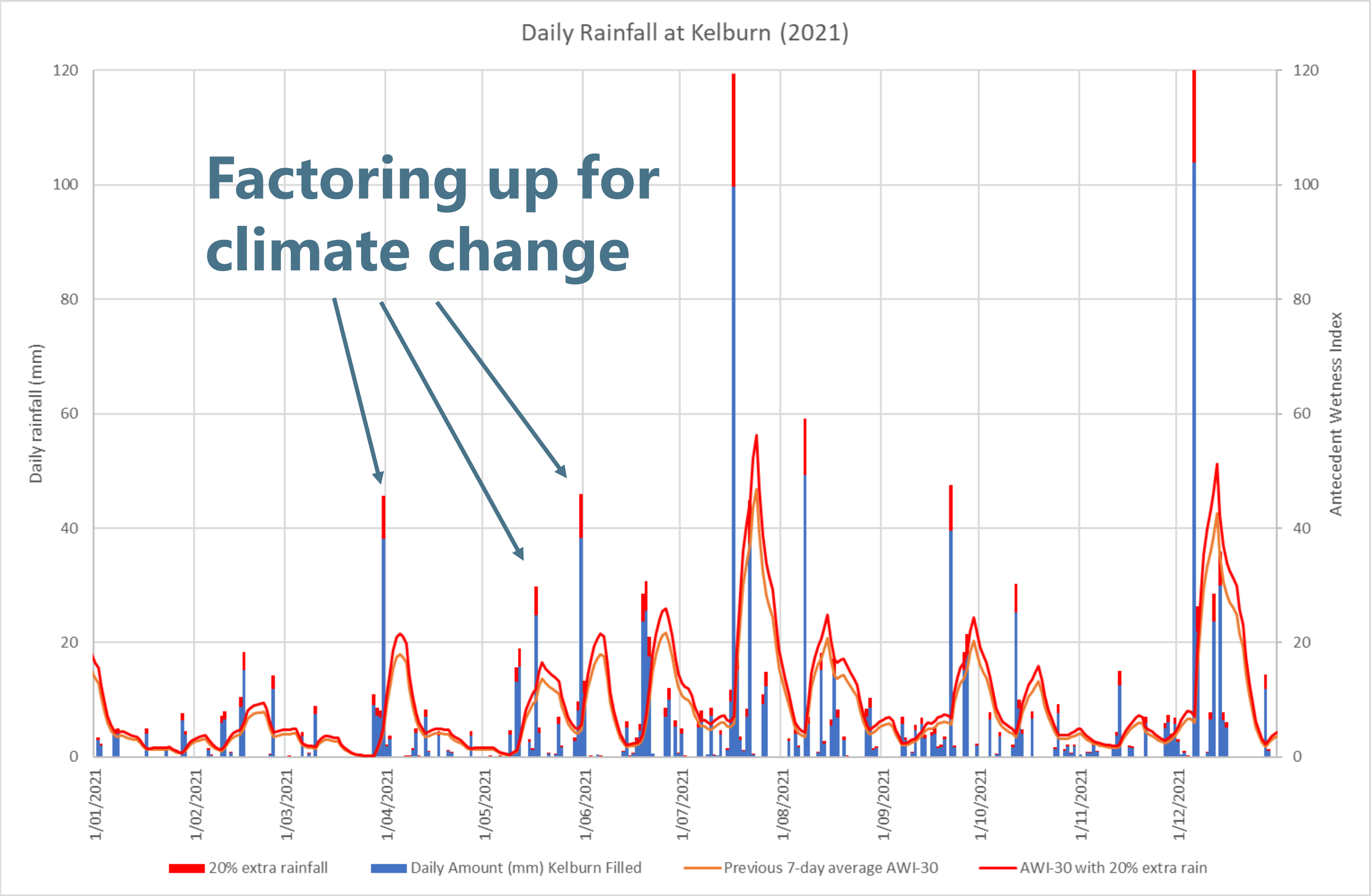
A sample rainfall record:



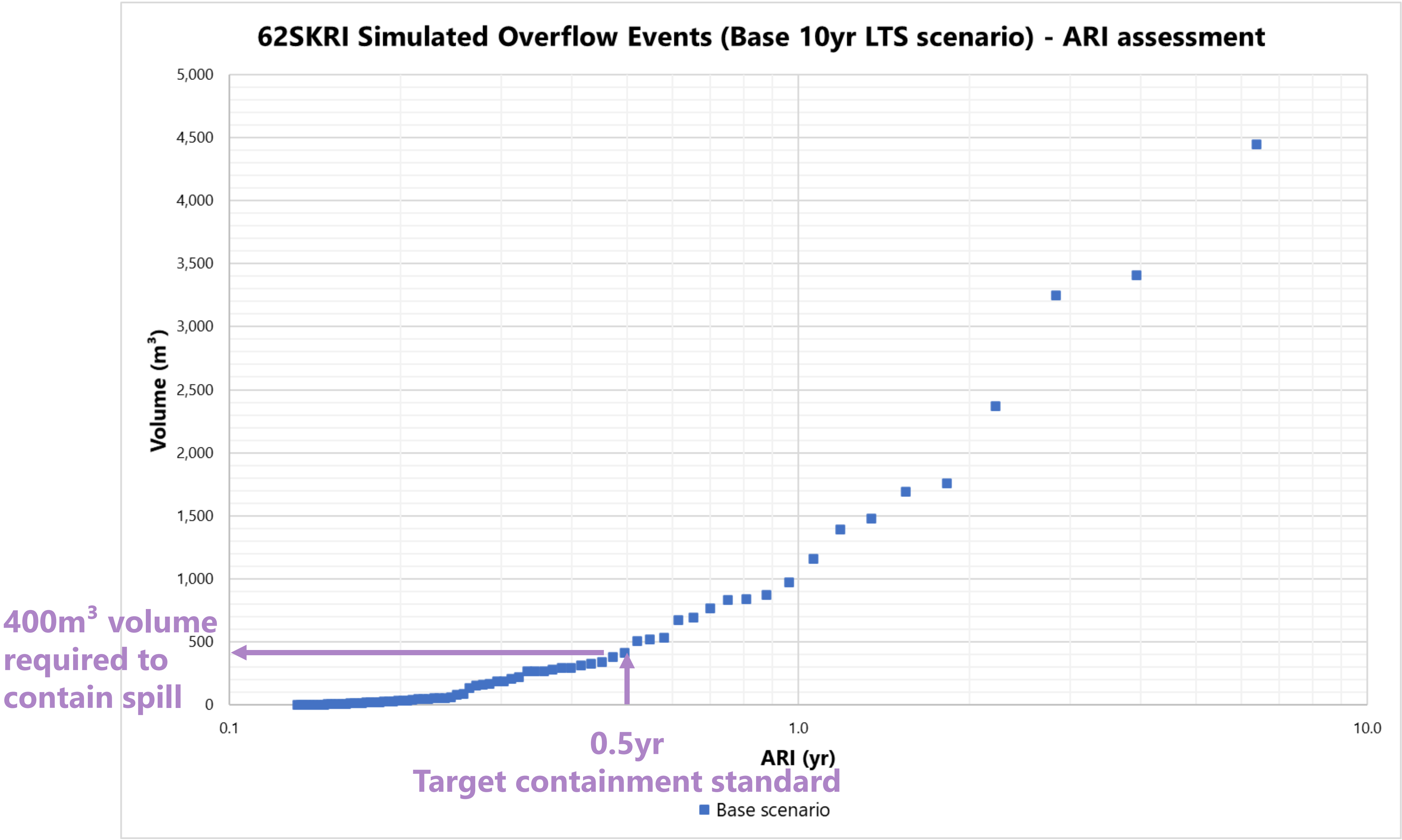

Daily Rainfall at Kelburn (2021)
Range of real events
...and dryer periods
Daily rainfall (mm)
Antecedent Wetness Index
120
100
80
60
40
20
0
1/01/2021
1/02/2021
1/03/2021
1/04/2021
1/05/2021
1/06/2021
1/07/2021
1/08/2021
1/09/2021
1/10/2021
1/11/2021
1/12/2021
Daily Amount (mm) Kelburn Filled
Previous 7-day average AWI-30



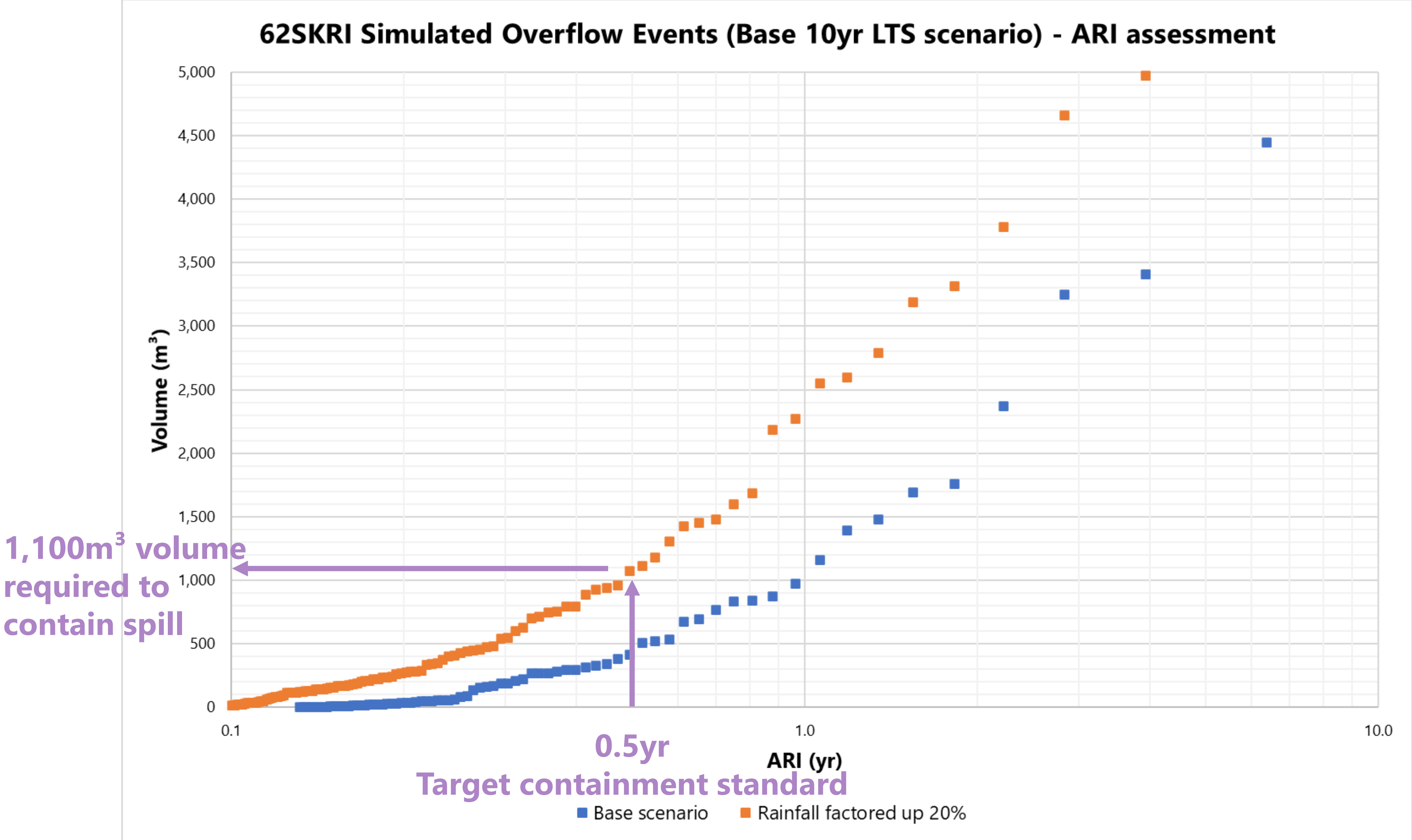
Daily Rainfall at Kelburn (2021)
Factoring up for climate change
Daily rainfall (mm)
Antecedent Wetness Index
0
20
40
60
80
100
120
1/01/2021
1/02/2021
1/03/2021
1/04/2021
1/05/2021
1/06/2021
1/07/2021
1/08/2021
1/09/2021
1/10/2021
1/11/2021
1/12/2021
20% extra rainfall
Daily Amount (mm) Kelburn Filled
Previous 7-day average AWI-30



Daily Rainfall at Kelburn (2021)
Factoring up for climate change
Daily rainfall (mm)
Antecedent Wetness Index
120
100
80
60
40
20
0
1/01/2021
1/02/2021
1/03/2021
1/04/2021
1/05/2021
1/06/2021
1/07/2021
1/08/2021
1/09/2021
1/10/2021
1/11/2021
1/12/2021
20% extra rainfall
Daily Amount (mm) Kelburn Filled
Previous 7-day average AWI-30
AWI-30 with 20% extra rain



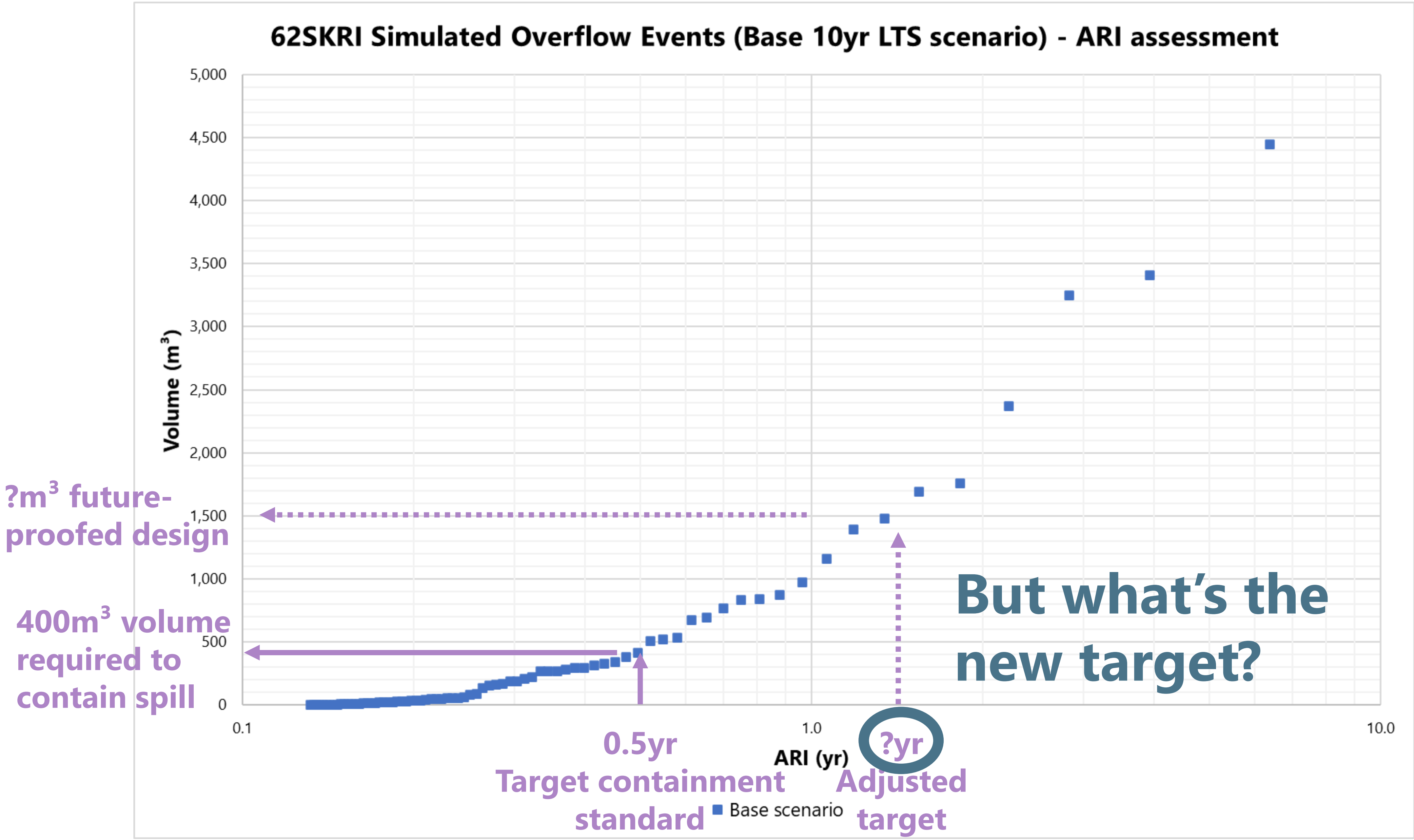
62SKRI Simulated Overflow Events (Base 10yr LTS scenario) - ARI assessment
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Volume (m³)
0.1
1.0
10.0
ARI (yr)
400m³ volume required to contain spill
0.5yr
Target containment standard
Base scenario



62SKRI Simulated Overflow Events (Base 10yr LTS scenario) - ARI assessment
Volume (m³)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.1
1.0
10.0
ARI (yr)
1,100m³ volume required to contain spill
0.5yr
Target containment standard
Base scenario
Rainfall factored up 20%

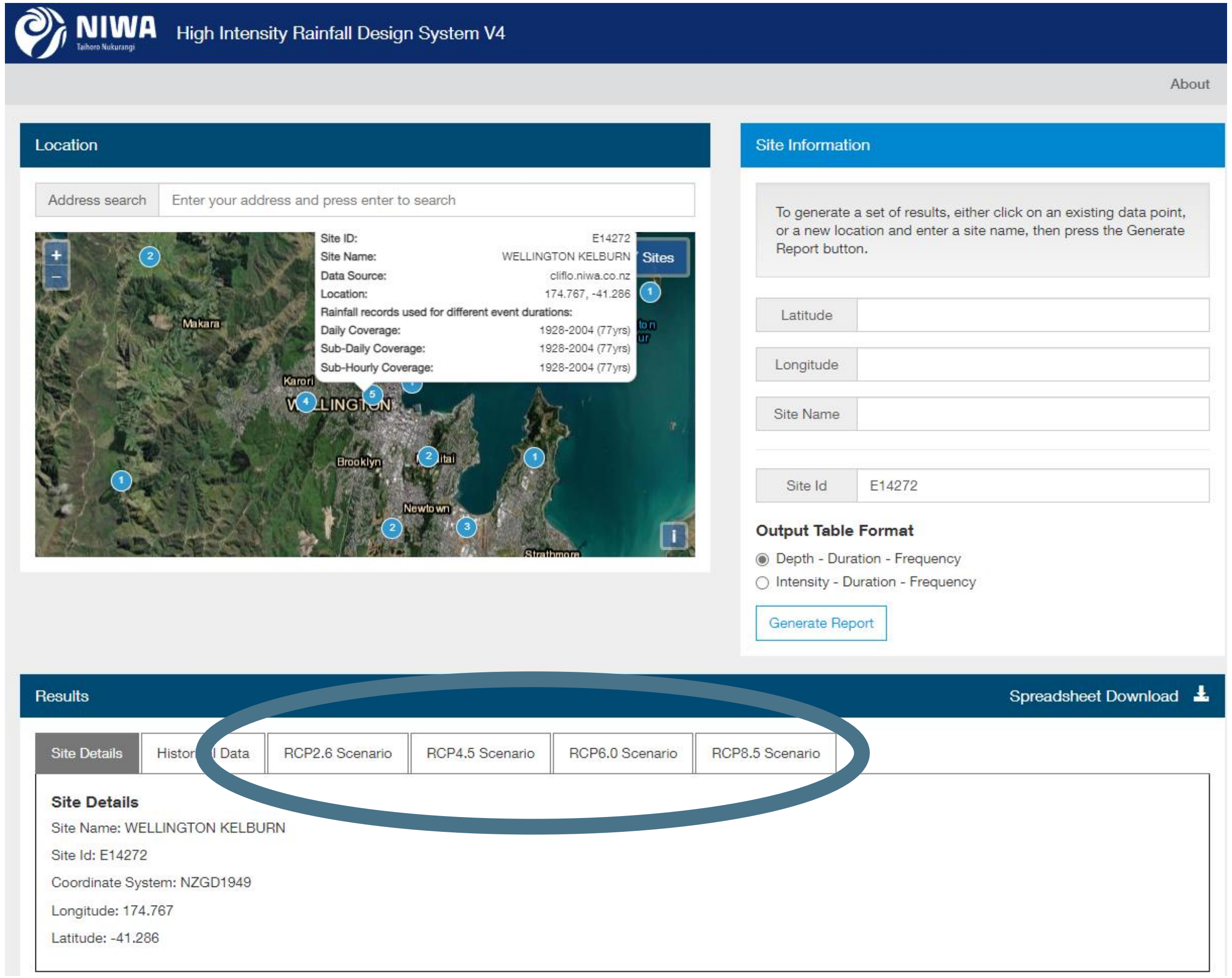
Alternative approaches

- Ideally obtain a “future” rainfall time series
  - Complex and expensive
  - Temporal downscaling of global climate models and/or extensive climate modelling at local scale
- OR use “historic” rainfall, and just adjust the target



62SKRI Simulated Overflow Events (Base 10yr LTS scenario) - ARI assessment
Volume (m³)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.1
1.0
10.0
ARI (yr)
Base scenario
?m³ future-proofed design
400m³ volume required to contain spill
0.5yr
Target containment standard
?yr
Adjusted target
But what's the new target?

Can we use HIRDS?



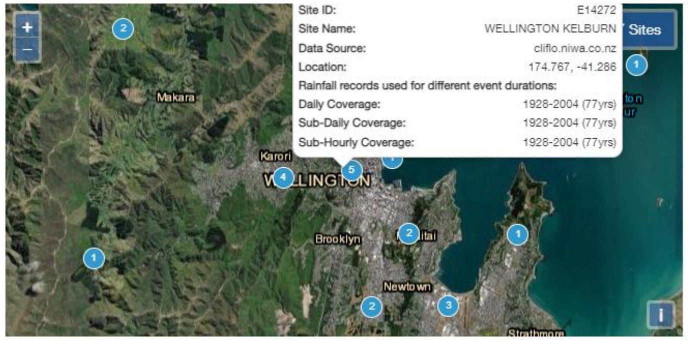
Can we use HIRDS? Spoiler alert: “no”

NIWA Taihoro Nukurangi — High Intensity Rainfall Design System V4

About

Location

Address search | Enter your address and press enter to search



Site Information

To generate a set of results, either click on an existing data point, or a new location and enter a site name, then press the Generate Report button.

Latitude

Longitude

Site Name

Site Id: E14272

Output Table Format

- (•) Depth - Duration - Frequency
- ( ) Intensity - Duration - Frequency

Generate Report

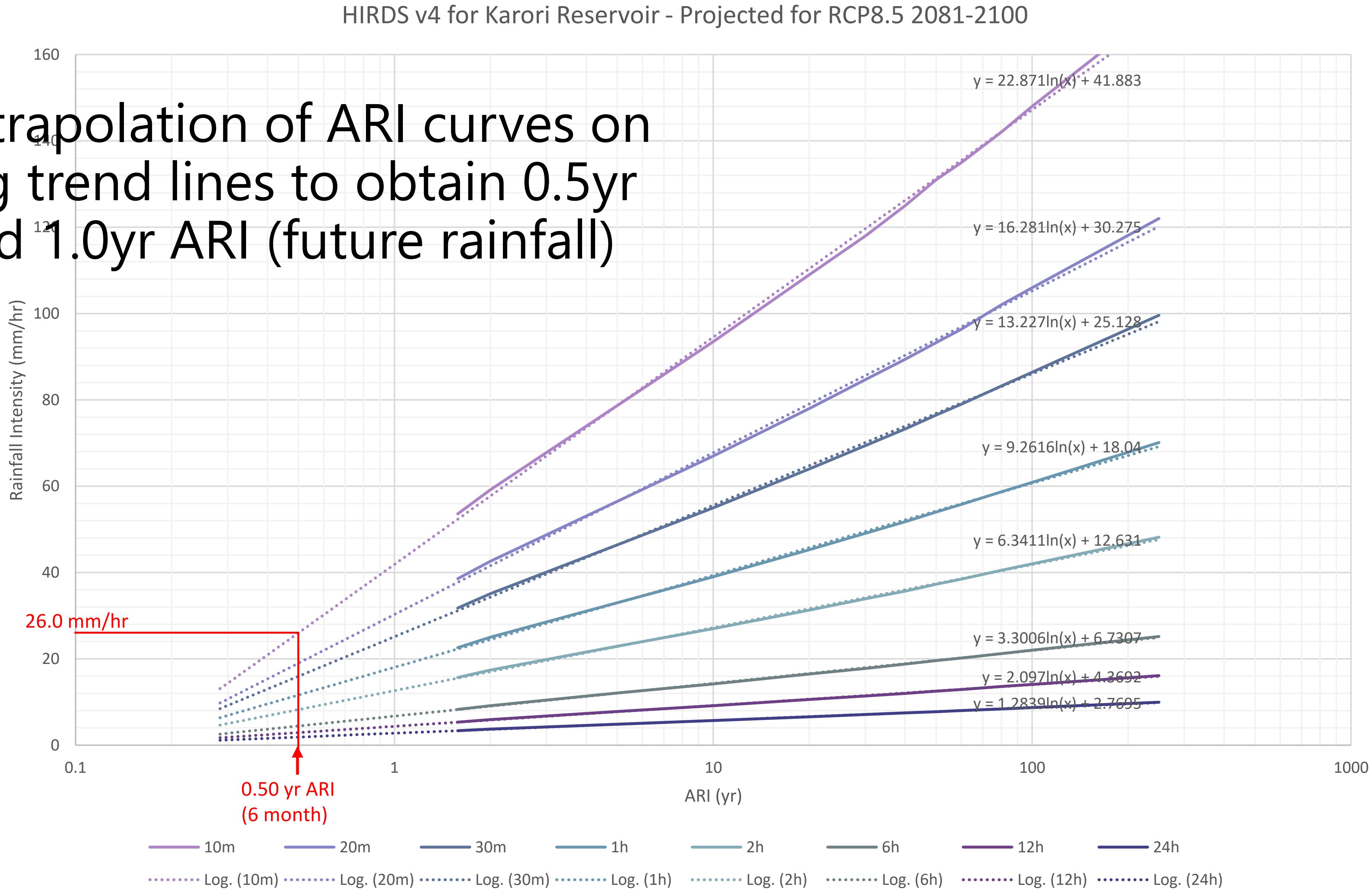
Results — Spreadsheet Download

Site Details | Historical Data | RCP2.6 Scenario | RCP4.5 Scenario | RCP6.0 Scenario | RCP8.5 Scenario

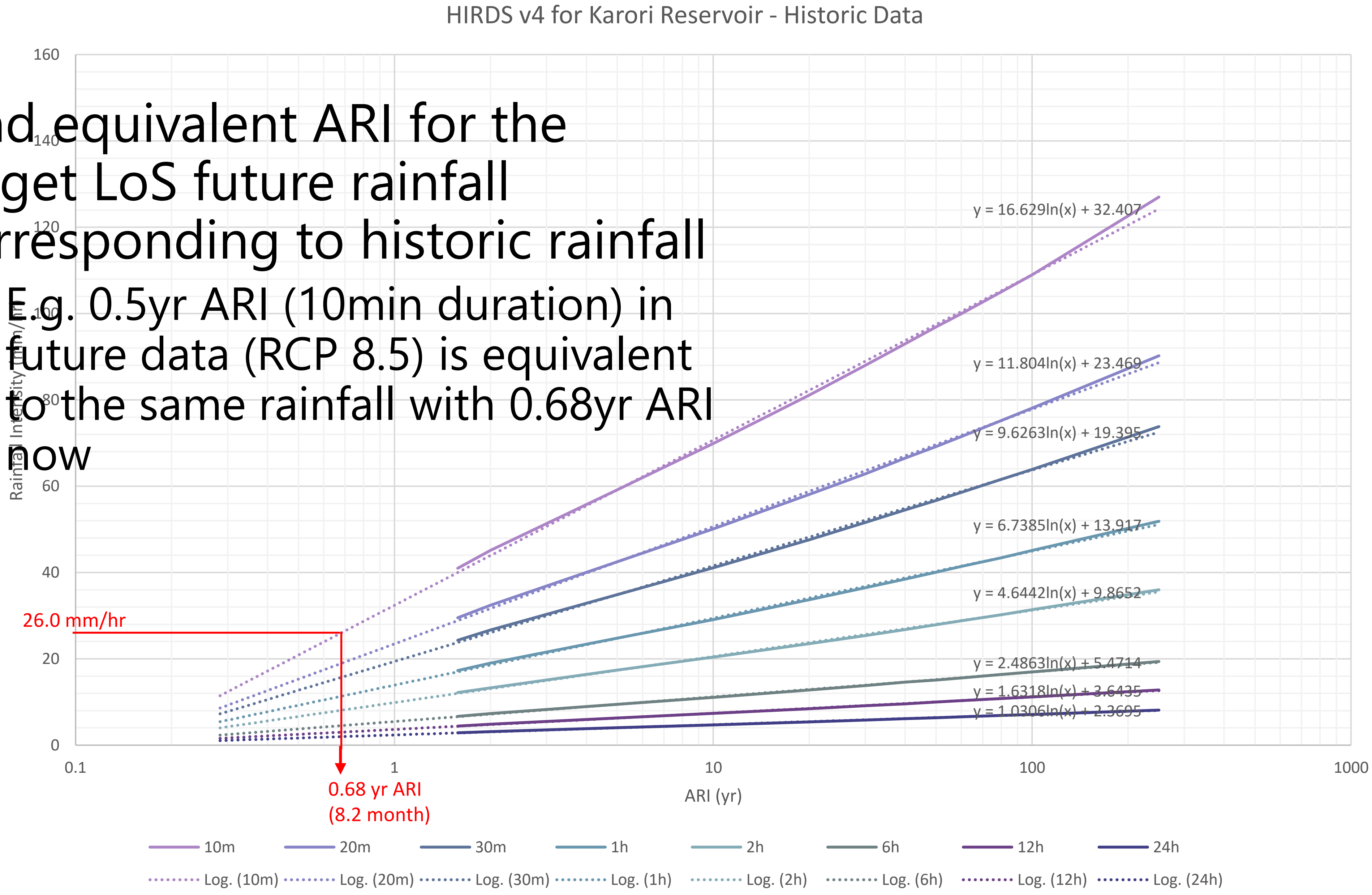
Rainfall depths (mm) :: RCP8.5 for the period 2031-2050

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	7.04	10.0	12.4	17.7	25.0	41.5	55.2	71.4	88.7	98.5	105	110
2	0.500	7.75	11.0	13.6	19.4	27.4	45.5	60.6	78.1	96.9	108	115	120
5	0.200	10.2	14.5	17.9	25.4	35.8	59.2	78.6	101	125	139	148	154

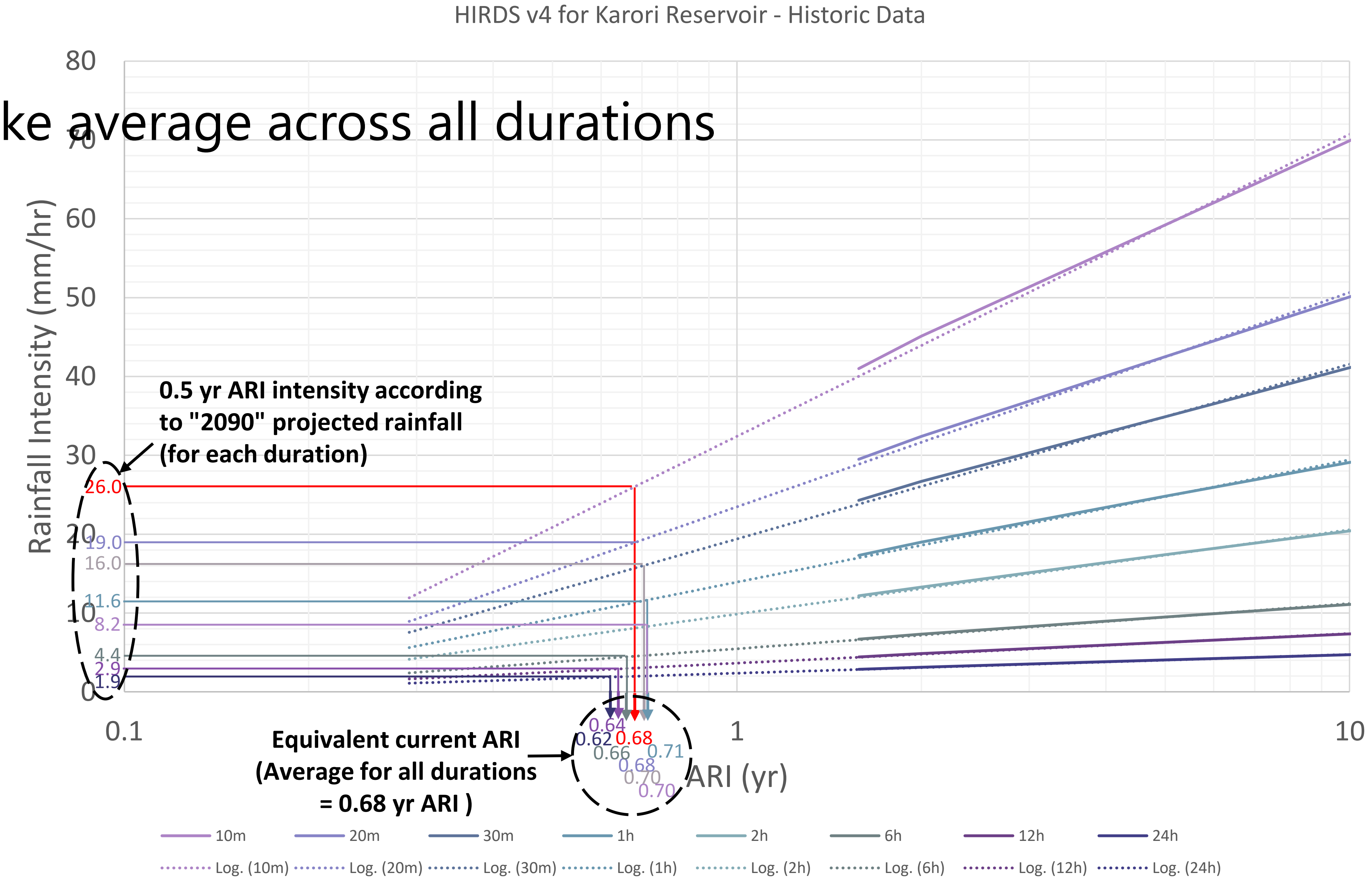
- Extrapolation of ARI curves on log trend lines to obtain 0.5yr and 1.0yr ARI (future rainfall)

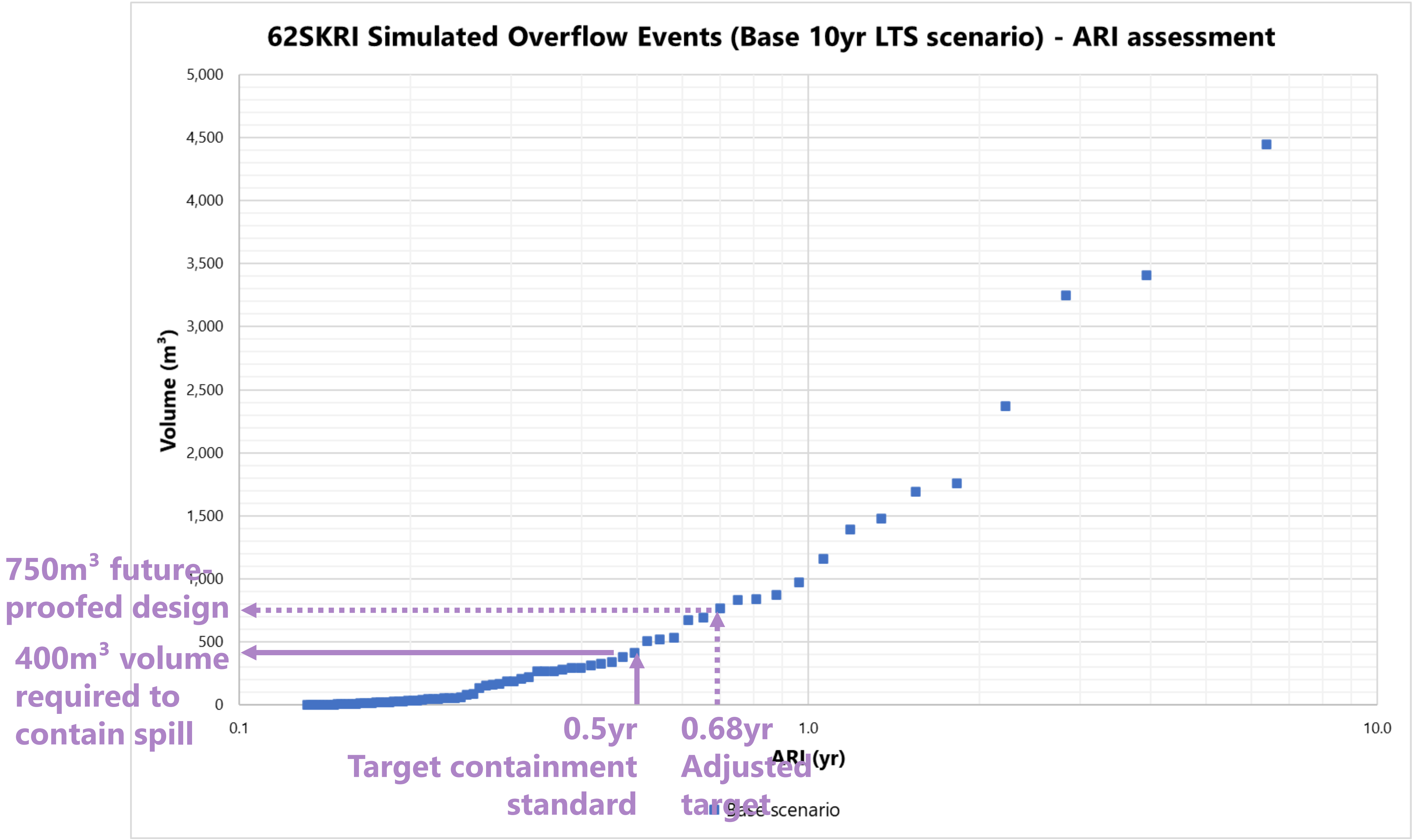


- Find equivalent ARI for the target LoS future rainfall corresponding to historic rainfall
  - E.g. 0.5yr ARI (10min duration) in future data (RCP 8.5) is equivalent to the same rainfall with 0.68yr ARI now



- Take average across all durations




62SKRI Simulated Overflow Events (Base 10yr LTS scenario) - ARI assessment
Volume (m³)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.1
1.0
10.0
ARI (yr)
Base scenario
750m³ future-proofed design
400m³ volume required to contain spill
0.5yr
Target containment standard
0.68yr
Adjusted target

NIWA review of method (Trevor Carey-Smith)

- What's wrong with this?
- HIRDS is tailored to extreme events (eg >10yr ARI).
- It is based on *annual* maxima.
- The HIRDS definition of ARI:
  - The average recurrence interval *between years* containing at least one event.
  - We can call this ARI_y
- Common definition of ARI:
  - The average recurrence interval *between events*
  - We can call this ARI_e

A statistics refresher

- Annual Exceedance Probability = AEP (probability that a certain value will be exceeded in a year).
- $ARI_y = 1/AEP$
- By definition ARI_y always > 1 (i.e. it only reaches 1 when AEP=1: we are 100% sure that the event will occur every year).

A statistics refresher

- Meanwhile, for ARI between *events*:
- $ARI_e = -\frac{1}{\ln(1-AEP)}$
- The two definitions can be related like this:
- $ARI_e = -\frac{1}{\ln\left(1-\frac{1}{ARI_y}\right)}$
- Note that when ARI_y = 1.58 years (the lowest return period provided in HIRDS), ARI_e = 1 year.
- For AEP>10% (i.e. “10 year event”), ARI_y and ARI_e are very similar.

A statistics refresher

- Recommended "event frequency descriptor terminology" from Australian Rainfall and Runoff.
- EY: exceedences per year
- AEP (% probablity)
- AEP (1 in x probability) *i.e. HIRDS ARI_y*
- ARI (Average Recurrence Interval)

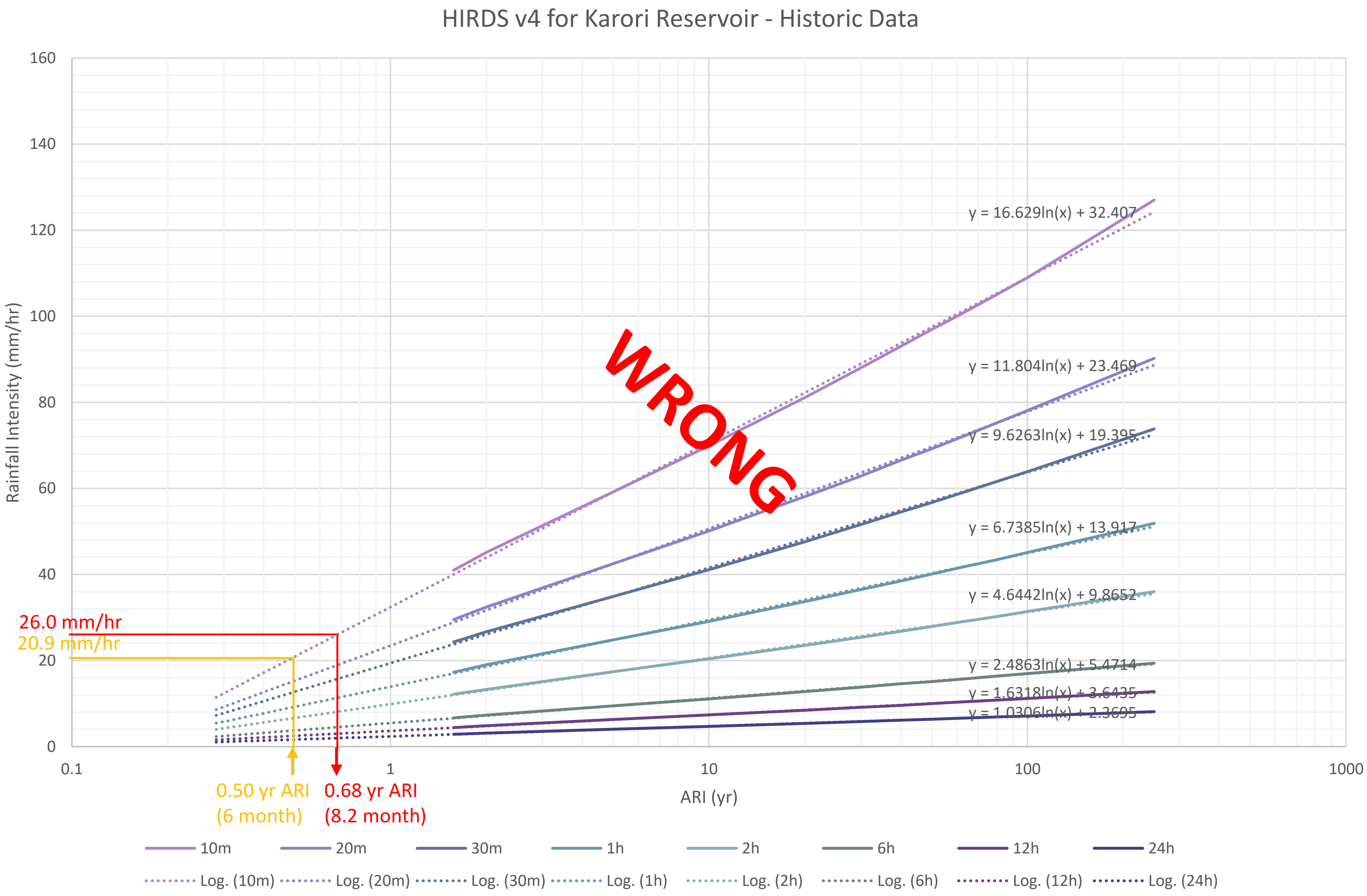
Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
Rare	0.11	10	10	9.49
	0.05	5	20	20
	0.02	2	50	50
Very Rare	0.01	1	100	100
	0.005	0.5	200	200
	0.002	0.2	500	500
	0.001	0.1	1000	1000
Extreme	0.0005	0.05	2000	2000
	0.0002	0.02	5000	5000
			PMP/ PMPDF	

"2 spills per year"

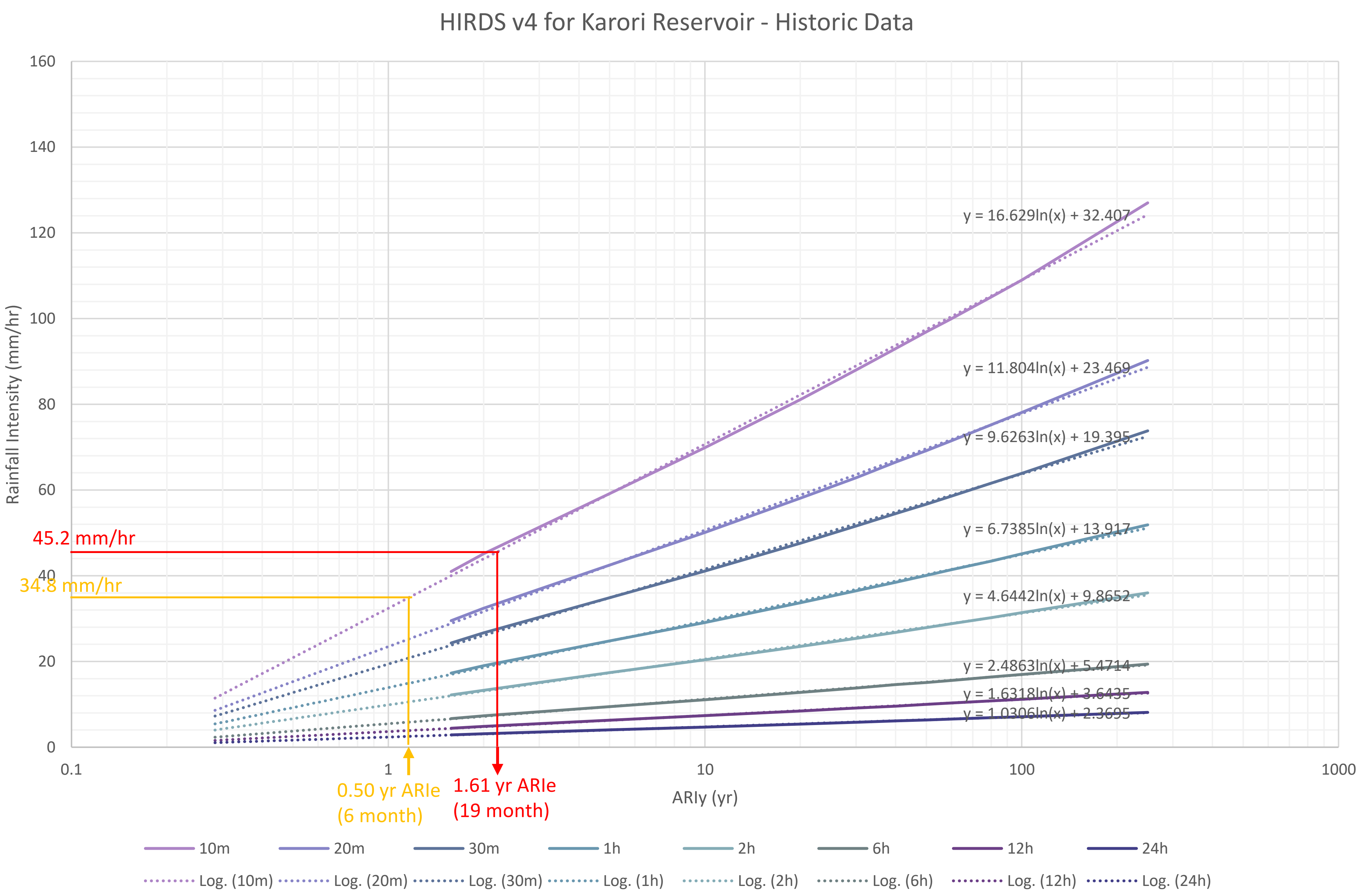
Similar for extreme events

Back to our moving target method

- The general idea is fine (says NIWA).
- The problem is using HIRDS to extrapolate to sub-annual frequencies.
- To do this, we first need to convert ARI_y to ARI_e



HIRDS v4 for Karori Reservoir - Historic Data
Rainfall Intensity (mm/hr)
ARI (yr)
0
20
40
60
80
100
120
140
160
0.1
1
10
100
1000
WRONG
y = 16.629ln(x) + 32.407
y = 11.804ln(x) + 23.469
y = 9.6263ln(x) + 19.395
y = 6.7385ln(x) + 13.917
y = 4.6442ln(x) + 9.8652
y = 2.4863ln(x) + 5.4714
y = 1.6318ln(x) + 3.6435
y = 1.0306ln(x) + 2.3695
26.0 mm/hr
20.9 mm/hr
0.50 yr ARI
(6 month)
0.68 yr ARI
(8.2 month)
10m
20m
30m
1h
2h
6h
12h
24h
Log. (10m)
Log. (20m)
Log. (30m)
Log. (1h)
Log. (2h)
Log. (6h)
Log. (12h)
Log. (24h)

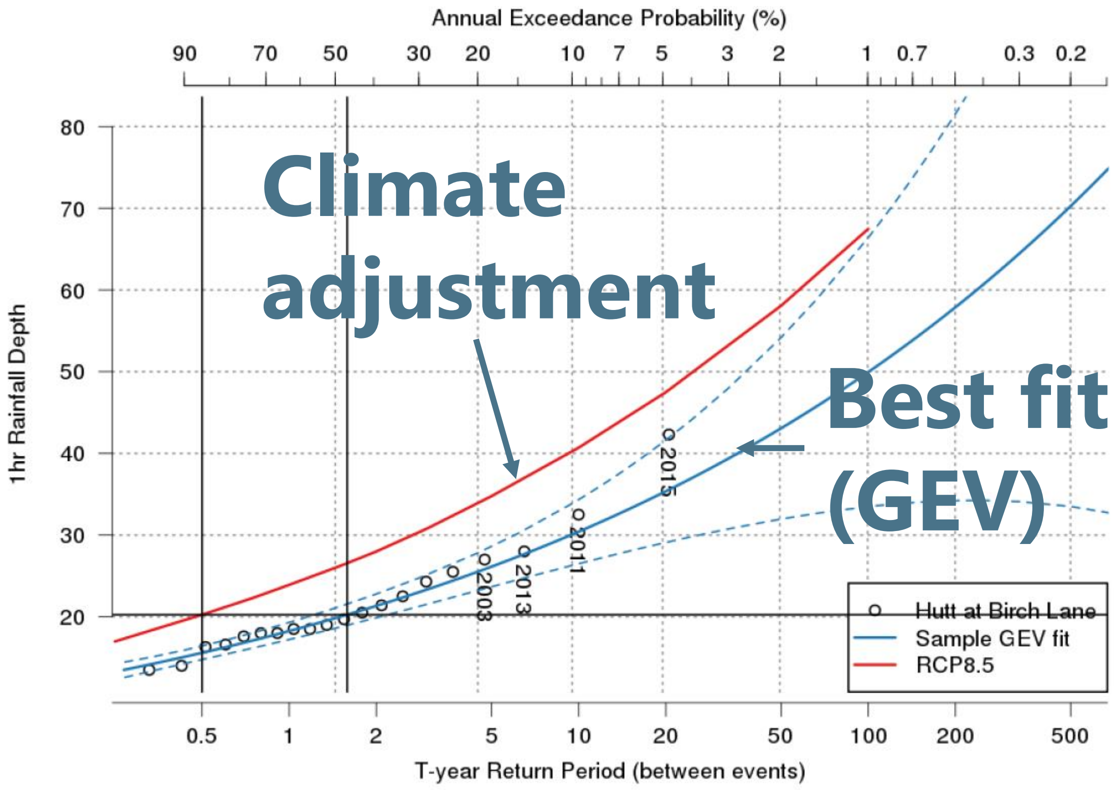


HIRDS v4 for Karori Reservoir - Historic Data
Rainfall Intensity (mm/hr)
ARIy (yr)
y = 16.629ln(x) + 32.407
y = 11.804ln(x) + 23.469
y = 9.6263ln(x) + 19.395
y = 6.7385ln(x) + 13.917
y = 4.6442ln(x) + 9.8652
y = 2.4863ln(x) + 5.4714
y = 1.6318ln(x) + 3.6435
y = 1.0306ln(x) + 2.3695
45.2 mm/hr
34.8 mm/hr
0.50 yr ARIe
(6 month)
1.61 yr ARIe
(19 month)
10m
20m
30m
1h
2h
6h
12h
24h
Log. (10m)
Log. (20m)
Log. (30m)
Log. (1h)
Log. (2h)
Log. (6h)
Log. (12h)
Log. (24h)

NIWA's solution

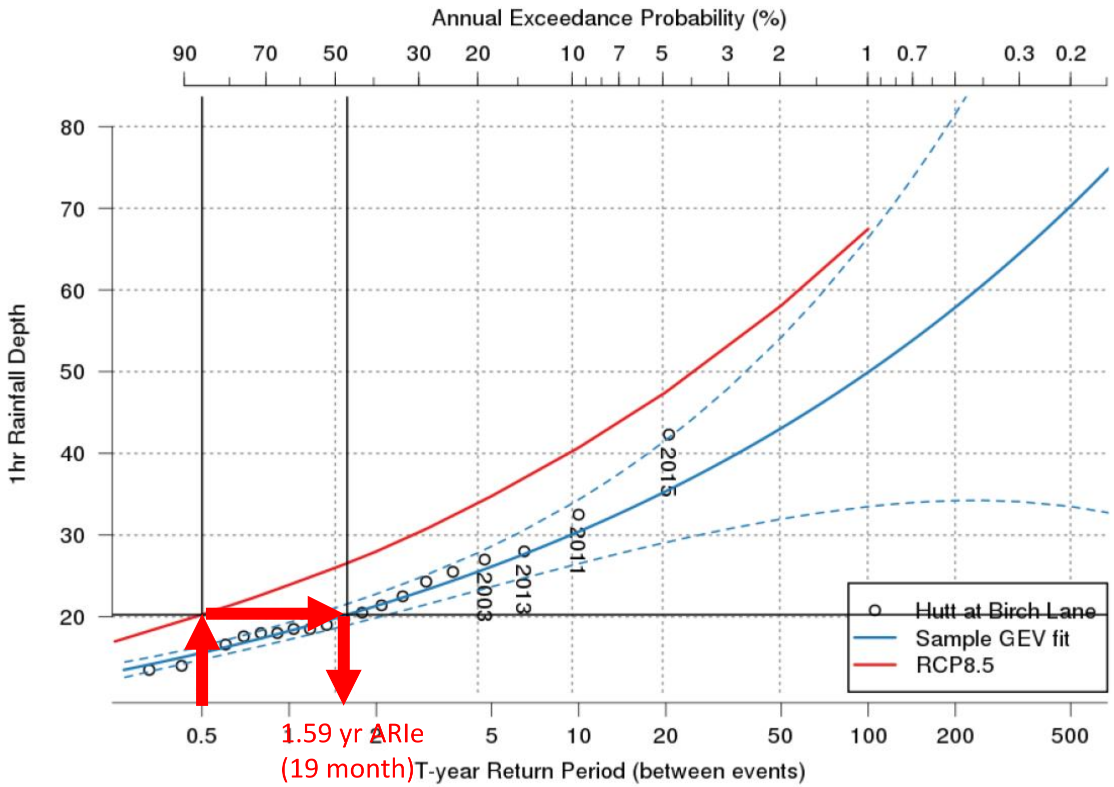
- Don't use HIRDS at all.
- For the selected rain gauges, extract "monthly maxima" (as opposed to the "annual maxima" series that HIRDS is based on)
- This will be better suited for assessing sub-annual frequencies.

NIWA's solution

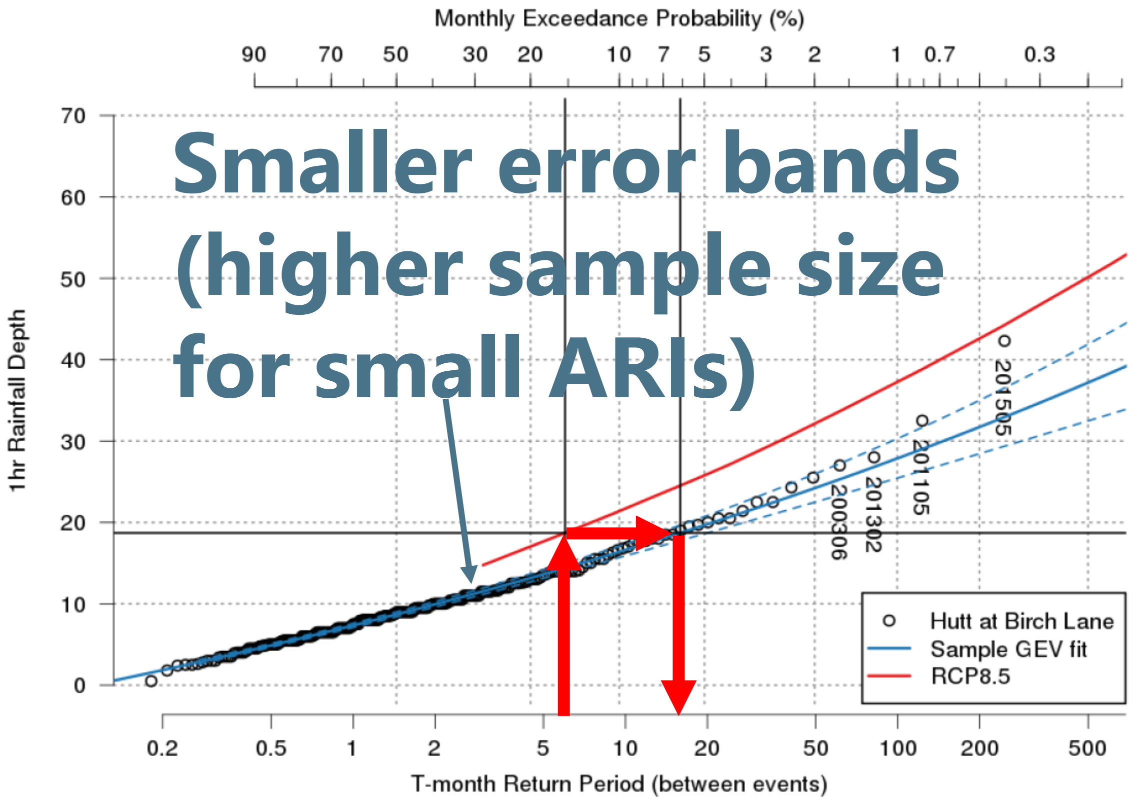


Annual maxima series (Hutt at Birch Lane) for 1hr duration plotted on a reduced Gumbel variate

NIWA's solution



Annual maxima series (Hutt at Birch Lane) for 1hr duration plotted on a reduced Gumbel variate



Monthly maxima series

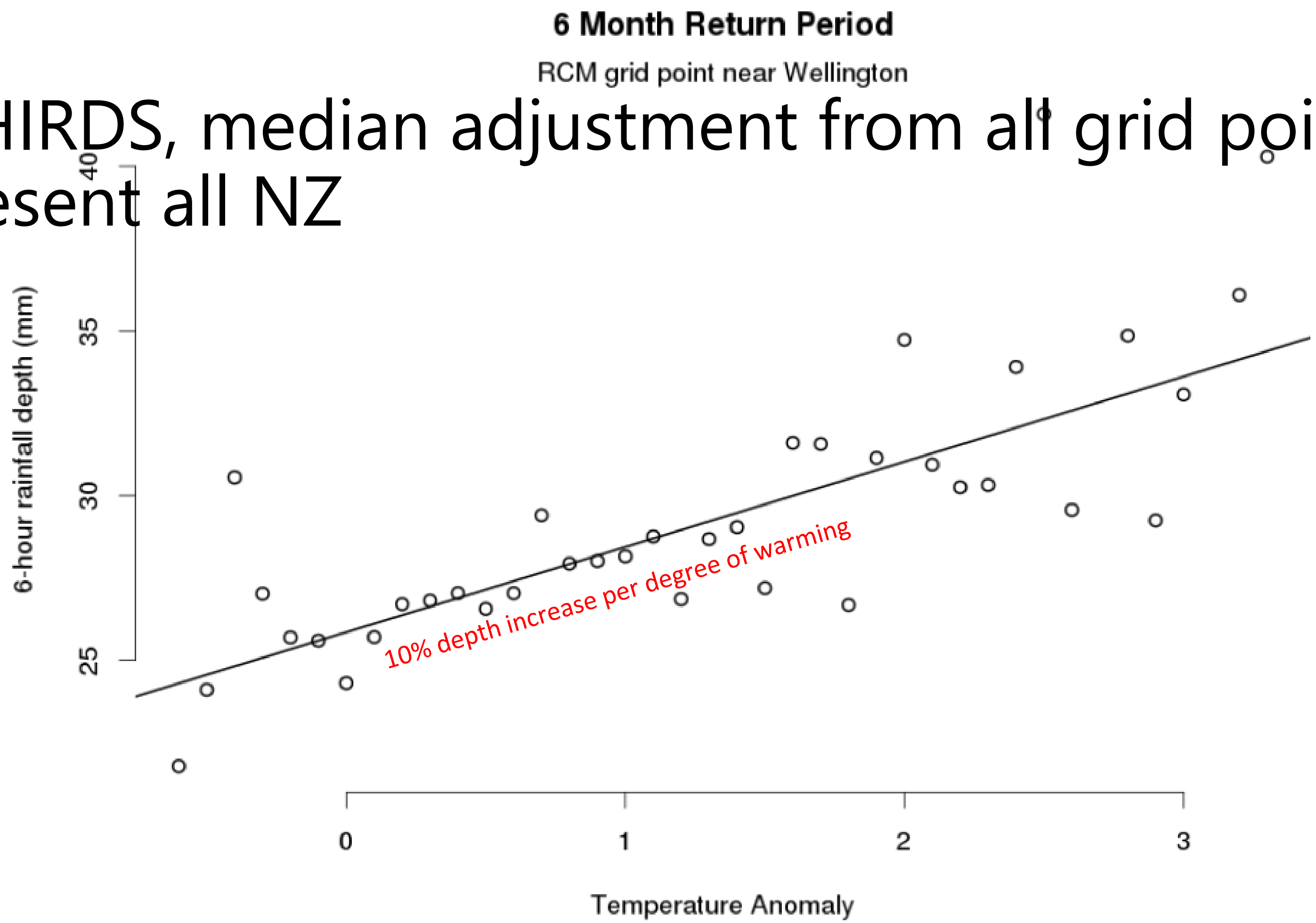
1.32 yr ARIe
(16 month)

Climate change adjustment factors

- Similar approach as used for HIRDS v4.
  - Six global climate models downscaled to provide hourly rainfall from 1970-2100, at 27km resolution, for four representative concentration pathways (RCP2.6, 4.5, 6.0 and 8.5)
- But assessed at monthly scale
  - For each 0.1°C temperature anomaly, ARI assessment of monthly maxima (for each duration).
  - Linear trend fitted to obtain "change in rainfall depth per degree of warming" for each ARI/duration.

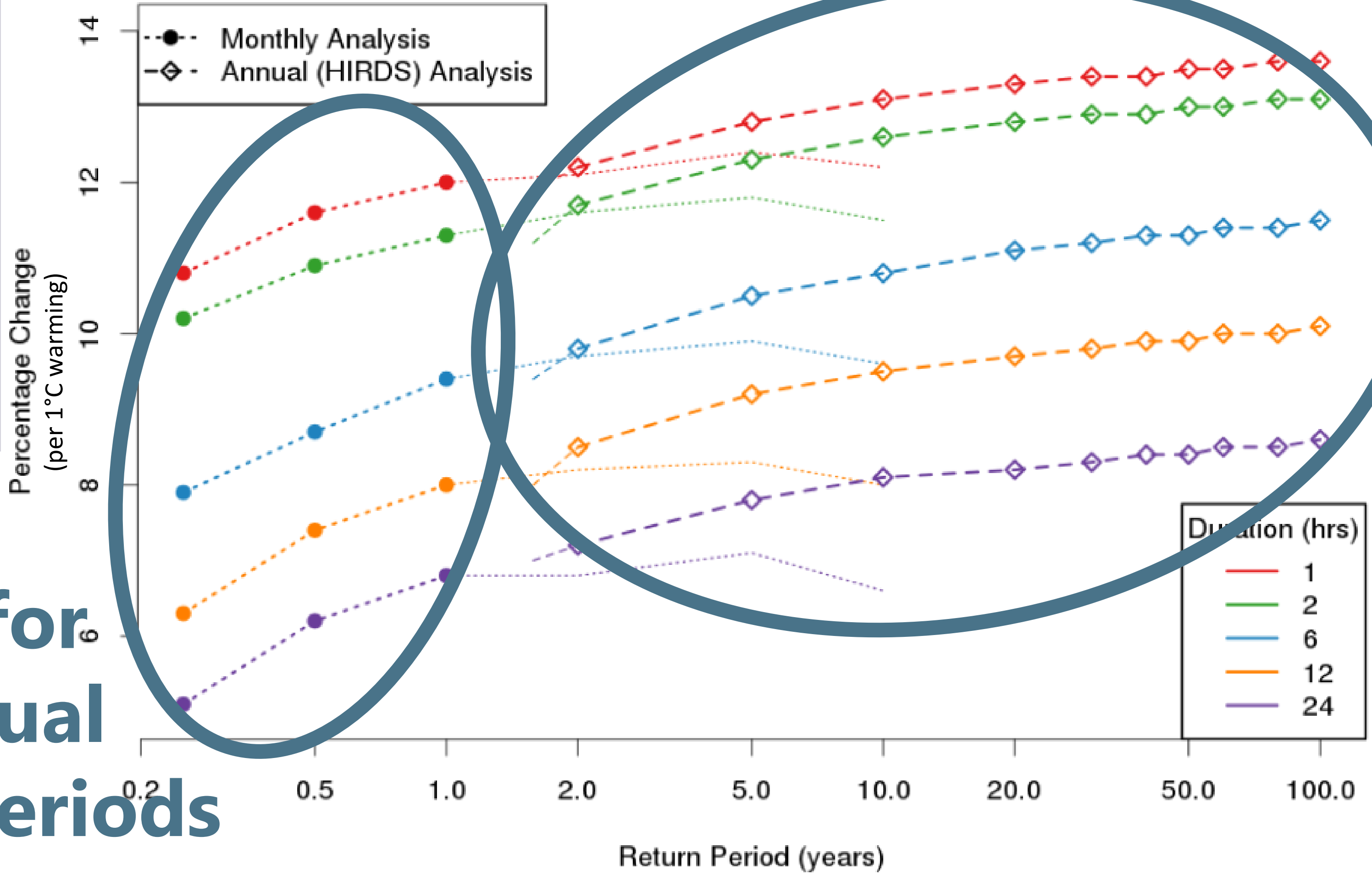
Climate change adjustment factors

- As for HIRDS, median adjustment from all grid points adopted to represent all NZ



Climate change adjustment factors

Warming has more impact on higher return periods, and shorter durations



Factors adopted in HIRDS

Factors for sub-annual return periods

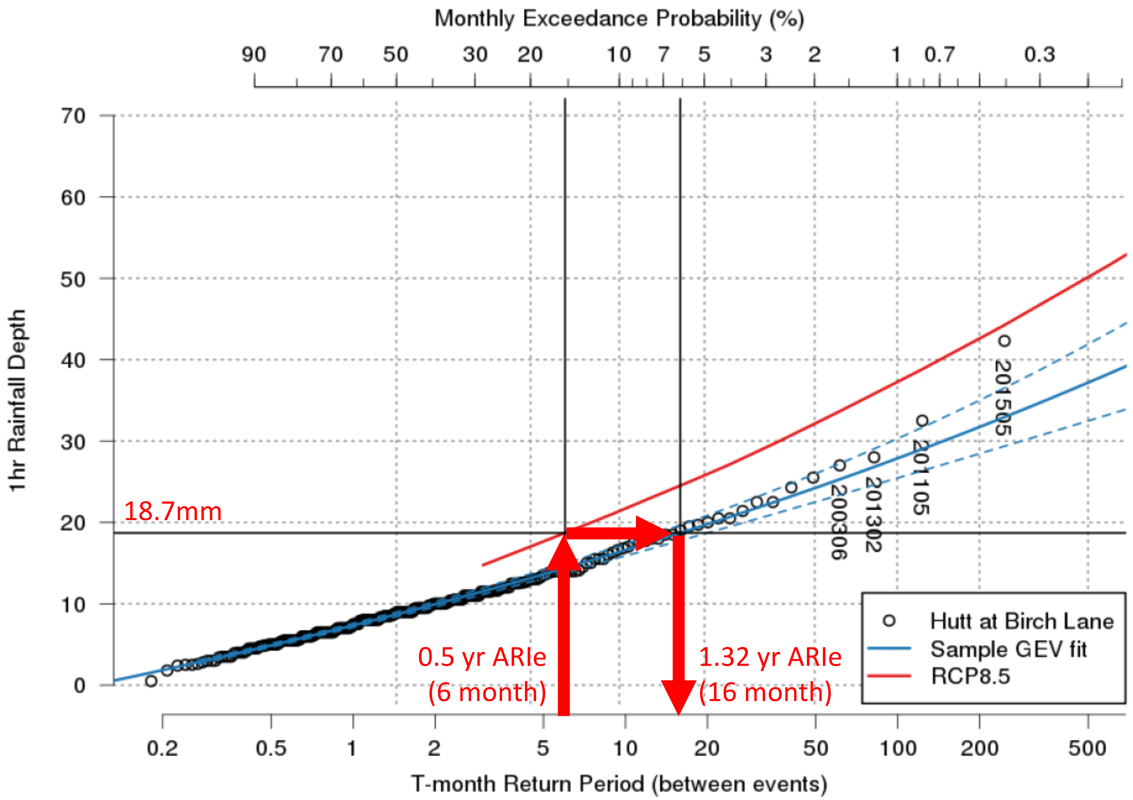
Climate change adjustment factors

Table 3: New Zealand land-average temperature increase relative to 1986—2005 for four future emissions scenarios. The three 21st century projections result from the average of six RCM model simulations (driven by different global climate models). The early 22nd century projections are based only on the subset of models that were available and so should be used with caution. After Table 8 in *Carey-Smith et al*. (2018).

	2031—2050	2056—2075	2081—2100	2101—2120
RCP 2.6	0.59	0.67	0.59	0.59 (4 model avg)
RCP 4.5	0.74	1.05	1.21	1.44 (5 model avg)
RCP 6.0	0.68	1.16	1.63	2.31 (CESM1-CAM5 only)
RCP 8.5	0.85	1.65	2.58	3.13 (3 model avg)

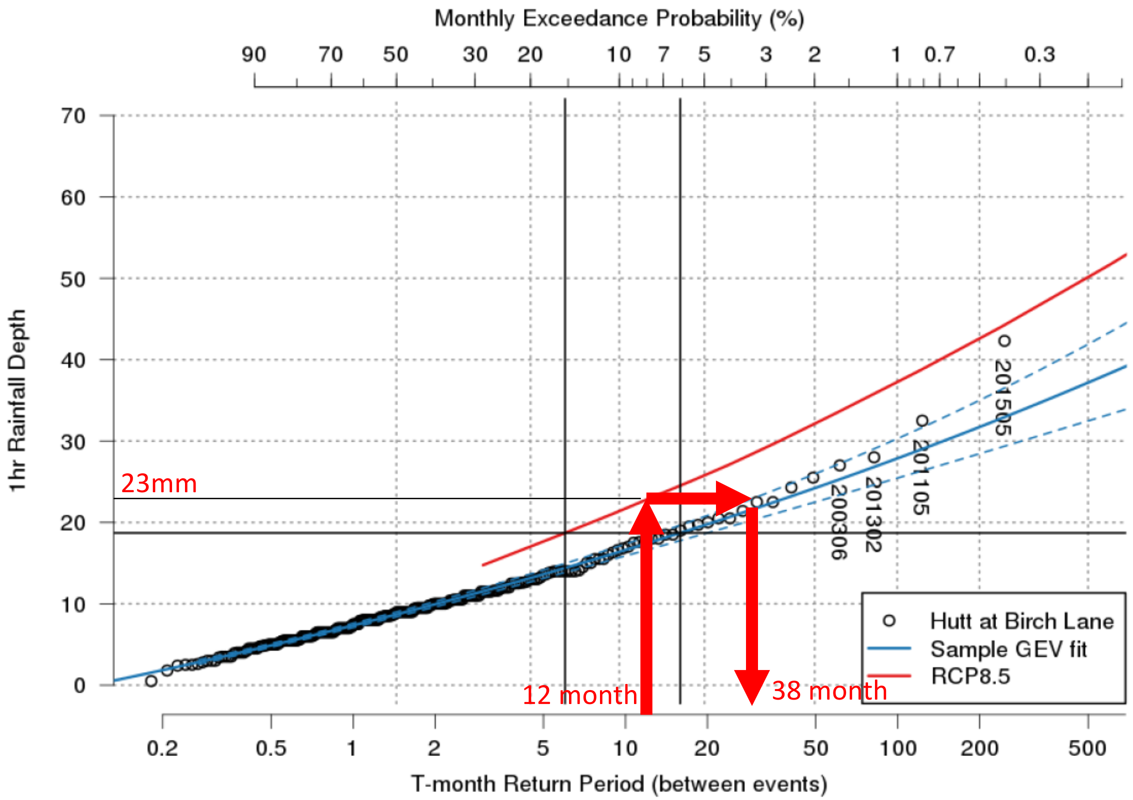
Warming for various time horizons

Equivalent 'current return periods'



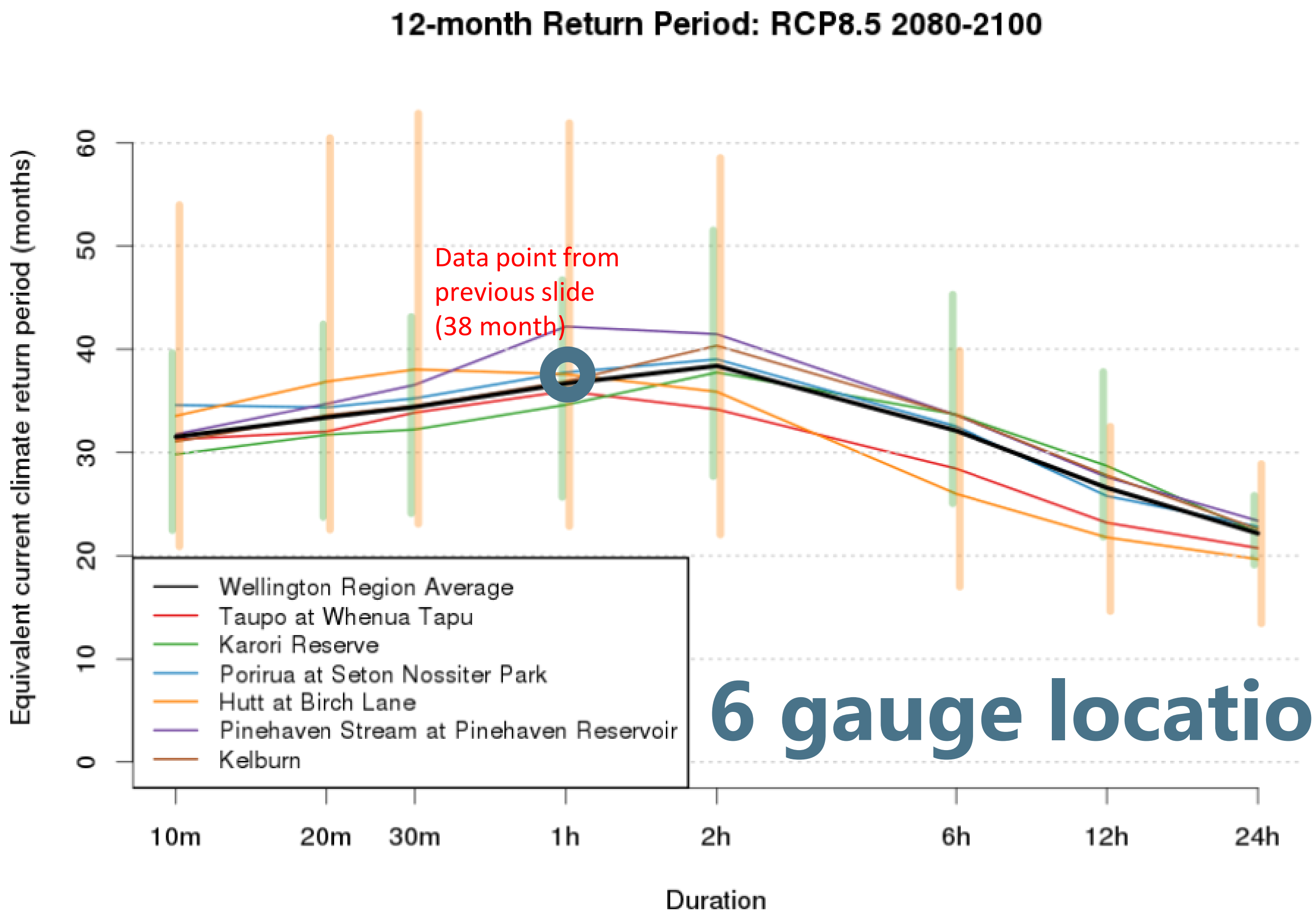
Monthly maxima series (Hutt at Birch Lane) for 1hr duration plotted on a reduced Gumbel variate

Equivalent ‘current return periods’



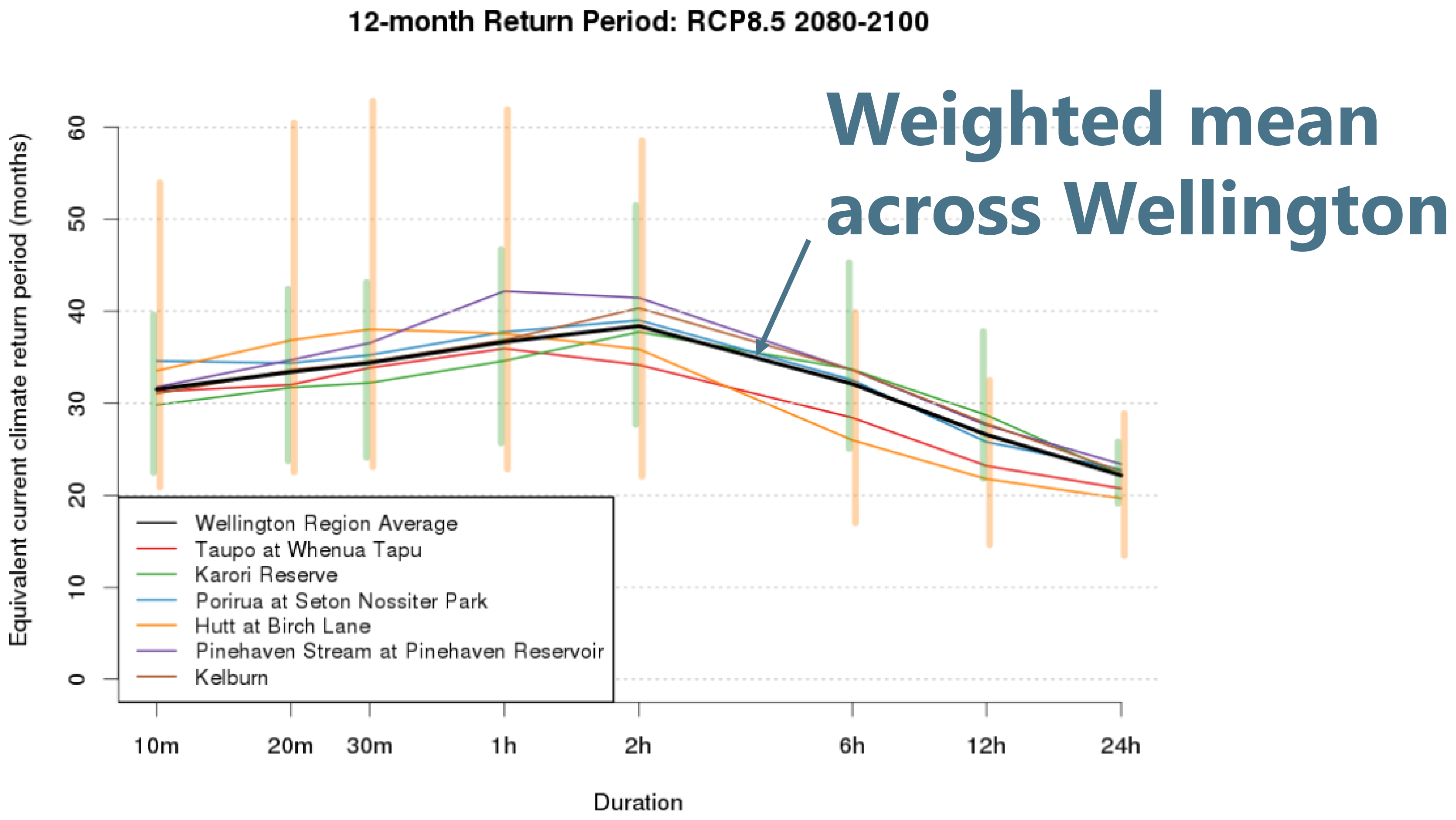
Monthly maxima series (Hutt at Birch Lane) for 1hr duration plotted on a reduced Gumbel variate

Equivalent ‘current return periods’

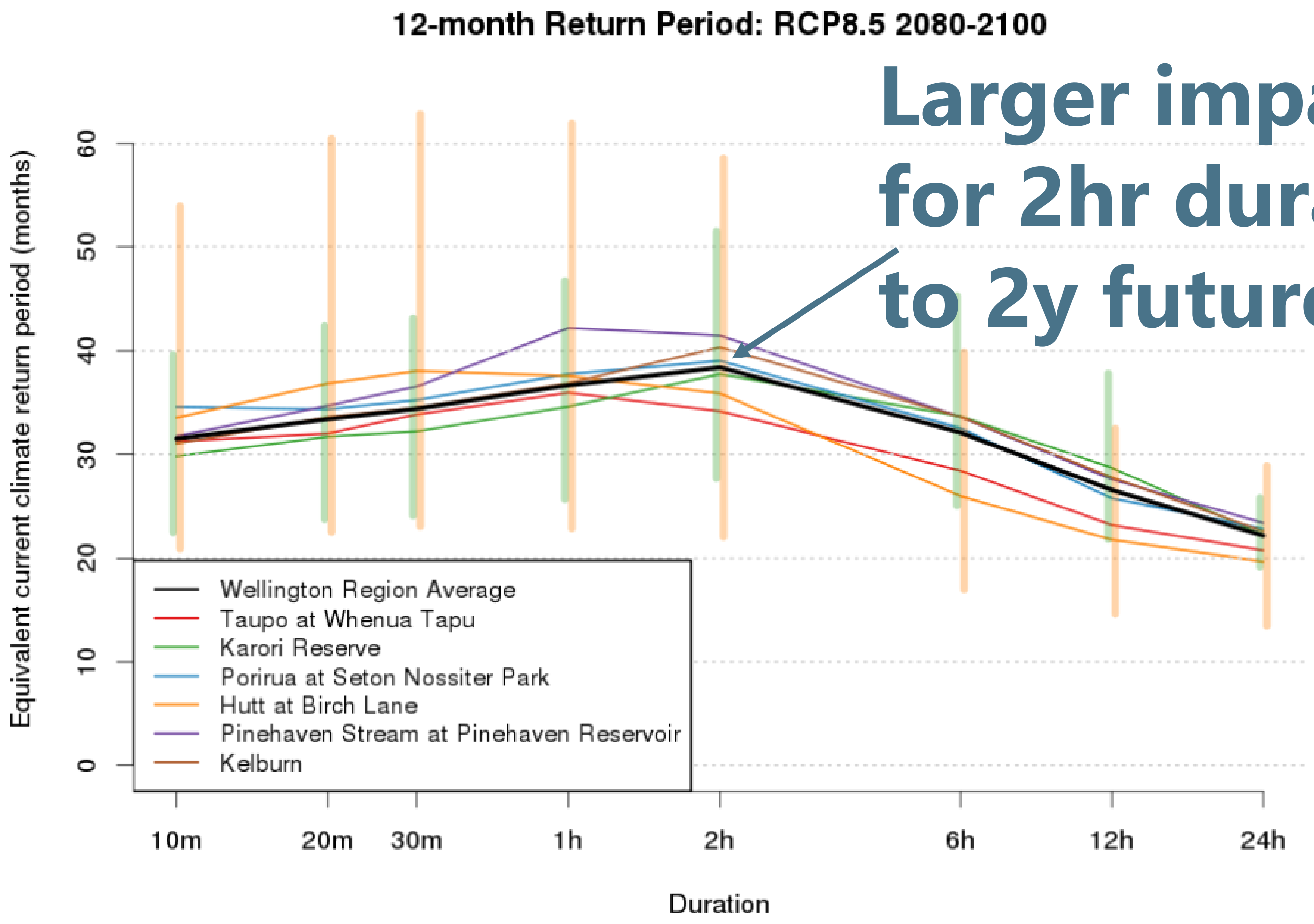


6 gauge locations

Equivalent 'current return periods'



Equivalent ‘current return periods’



Larger impact estimated for 2hr duration (for 3m to 2y future ARI)

Equivalent 'current return periods'

Select duration appropriate to catchment →

Table 4: Wellington Regional average equivalent current climate return. Return periods shown in months for a range of expected return periods during different emissions scenarios and future time periods

Duration	Target Return Period	Equivalent Current Climate Return Period 2031-2050 RCP2.6	RCP4.5	RCP6.0	RCP8.5	2081-2100 RCP2.6	RCP4.5	RCP6.0	RCP8.5
10 min	3	3.5	3.7	3.6	3.8	3.5	4.2	4.7	6.0
20 min	3	3.6	3.7	3.7	3.8	3.6	4.3	4.8	6.2
30 min	3	3.6	3.7	3.7	3.9	3.6	4.3	4.9	6.3
1 hr	3	3.6	3.8	3.7	3.9	3.6	4.4	4.9	6.5
2 hr	3	3.6	3.8	3.7	3.9	3.6	4.3	4.9	6.5
6 hr	3	3.4	3.6	3.5	3.7	3.4	4.0	4.4	5.4
12 hr	3	3.3	3.4	3.4	3.5	3.3	3.7	4.0	4.7
24 hr	3	3.2	3.3	3.3	3.4	3.2	3.5	3.7	4.2
10 min	6	7.3	7.7	7.6	8.0	7.3	9.0	10	14
20 min	6	7.4	7.8	7.7	8.1	7.4	9.2	11	15
30 min	6	7.5	7.9	7.7	8.2	7.5	9.3	11	15
1 hr	6	7.5	8.0	7.8	8.3	7.5	9.5	11	16
2 hr	6	7.5	8.0	7.8	8.3	7.5	9.6	11	16
6 hr	6	7.2	7.5	7.4	7.8	7.2	8.7	9.9	13
12 hr	6	6.9	7.2	7.1	7.4	6.9	8.1	9.0	11
24 hr	6	6.7	6.9	6.8	7.1	6.7	7.6	8.2	9.8

Equivalent ‘current return periods’

Select target return period (“Containment Standard”)

Table 4: Wellington Regional average equivalent current climate return. Return periods shown in months for a range of expected return periods during different emissions scenarios and future time periods

Duration	Target Return Period	Equivalent Current Climate Return Period 2031-2050 RCP2.6	2031-2050 RCP4.5	2031-2050 RCP6.0	2031-2050 RCP8.5	2081-2100 RCP2.6	2081-2100 RCP4.5	2081-2100 RCP6.0	2081-2100 RCP8.5
10 min	3	3.5	3.7	3.6	3.8	3.5	4.2	4.7	6.0
20 min	3	3.6	3.7	3.7	3.8	3.6	4.3	4.8	6.2
30 min	3	3.6	3.7	3.7	3.9	3.6	4.3	4.9	6.3
1 hr	3	3.6	3.8	3.7	3.9	3.6	4.4	4.9	6.5
2 hr	3	3.6	3.8	3.7	3.9	3.6	4.3	4.9	6.5
6 hr	3	3.4	3.6	3.5	3.7	3.4	4.0	4.4	5.4
12 hr	3	3.3	3.4	3.4	3.5	3.3	3.7	4.0	4.7
24 hr	3	3.2	3.3	3.3	3.4	3.2	3.5	3.7	4.2
10 min	6	7.3	7.7	7.6	8.0	7.3	9.0	10	14
20 min	6	7.4	7.8	7.7	8.1	7.4	9.2	11	15
30 min	6	7.5	7.9	7.7	8.2	7.5	9.3	11	15
1 hr	6	7.5	8.0	7.8	8.3	7.5	9.5	11	16
2 hr	6	7.5	8.0	7.8	8.3	7.5	9.6	11	16
6 hr	6	7.2	7.5	7.4	7.8	7.2	8.7	9.9	13
12 hr	6	6.9	7.2	7.1	7.4	6.9	8.1	9.0	11
24 hr	6	6.7	6.9	6.8	7.1	6.7	7.6	8.2	9.8

Equivalent 'current return periods'

Table 4: Wellington Regional average equivalent current climate return. Return periods shown in months for a range of expected return periods during different emissions scenarios and future time periods

Duration	Target Return Period	Equivalent Current Climate Return Period 2031-2050				2081-2100			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10 min	3	3.5	3.7	3.6	3.8	3.5	4.2	4.7	6.0
20 min	3	3.6	3.7	3.7	3.8	3.6	4.3	4.8	6.2
30 min	3	3.6	3.7	3.7	3.9	3.6	4.3	4.9	6.3
1 hr	3	3.6	3.8	3.7	3.9	3.6	4.4	4.9	6.5
2 hr	3	3.6	3.8	3.7	3.9	3.6	4.3	4.9	6.5
6 hr	3	3.4	3.6	3.5	3.7	3.4	4.0	4.4	5.4
12 hr	3	3.3	3.4	3.4	3.5	3.3	3.7	4.0	4.7
24 hr	3	3.2	3.3	3.3	3.4	3.2	3.5	3.7	4.2
10 min	6	7.3	7.7	7.6	8.0	7.3	9.0	10	14
20 min	6	7.4	7.8	7.7	8.1	7.4	9.2	11	15
30 min	6	7.5	7.9	7.7	8.2	7.5	9.3	11	15
1 hr	6	7.5	8.0	7.8	8.3	7.5	9.5	11	16
2 hr	6	7.5	8.0	7.8	8.3	7.5	9.6	11	16
6 hr	6	7.2	7.5	7.4	7.8	7.2	8.7	9.9	13
12 hr	6	6.9	7.2	7.1	7.4	6.9	8.1	9.0	11
24 hr	6	6.7	6.9	6.8	7.1	6.7	7.6	8.2	9.8

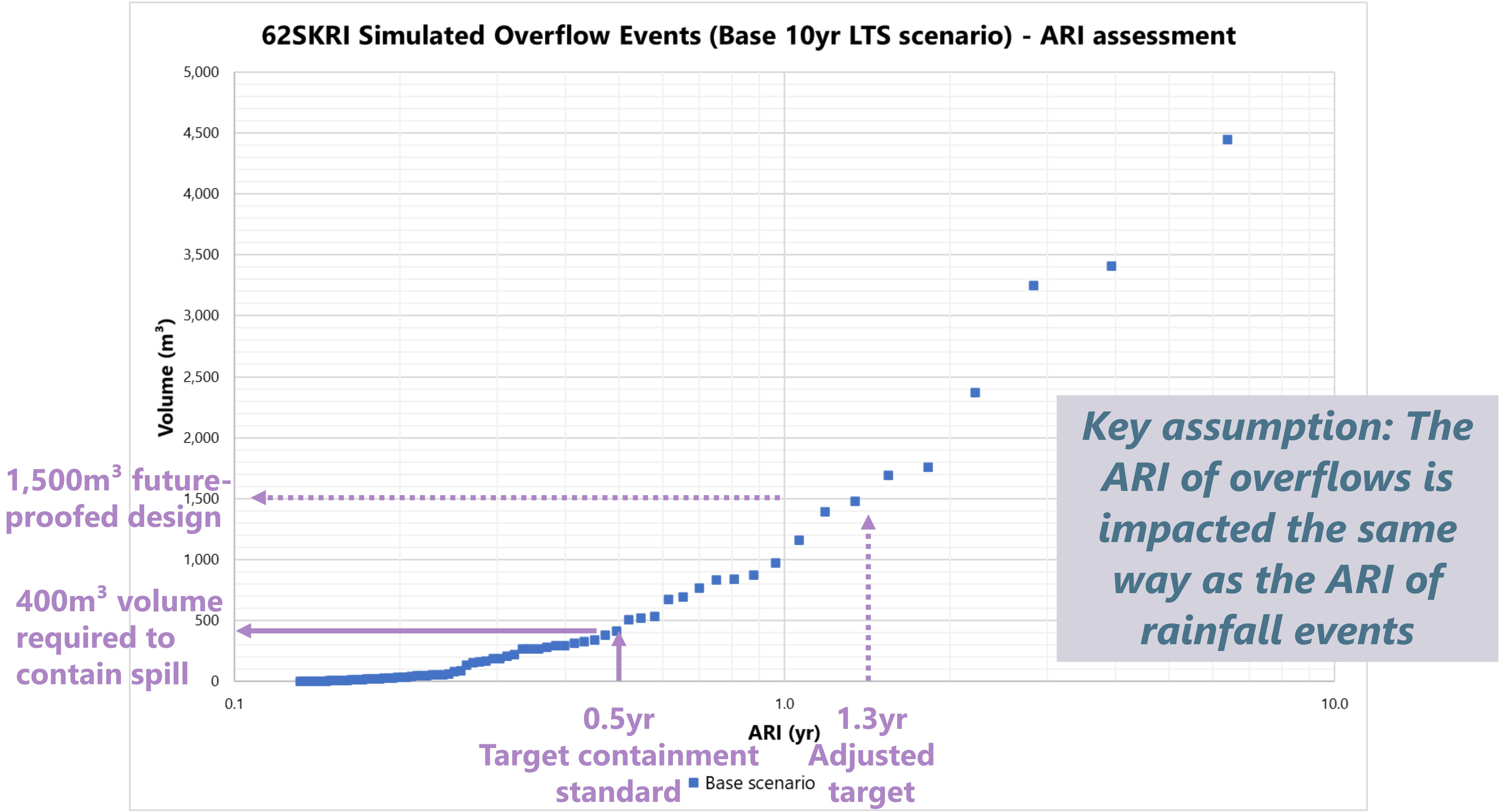
Select appropriate planning horizon (timeframe and RCP)

Equivalent ‘current return periods’

Table 4: Wellington Regional average equivalent current climate return. Return periods shown in months for a range of expected return periods during different emissions scenarios and future time periods

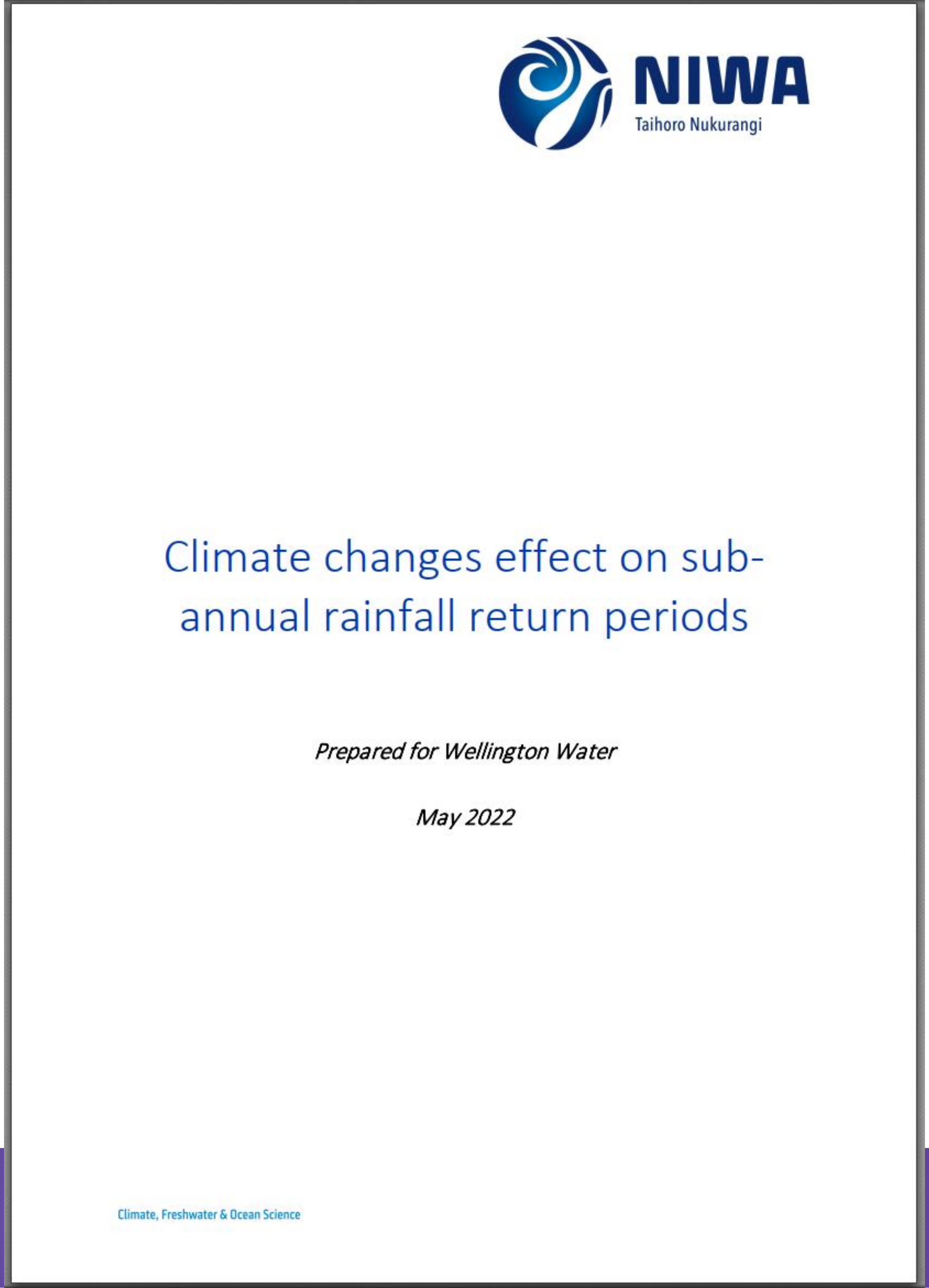
Duration	Target Return Period	Equivalent Current Climate Return Period							
		2031-2050				2081-2100			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10 min	3	3.5	3.7	3.6	3.8	3.5	4.2	4.7	6.0
20 min	3	3.6	3.7	3.7	3.8	3.6	4.3	4.8	6.2
30 min	3	3.6	3.7	3.7	3.9	3.6	4.3	4.9	6.3
1 hr	3	3.6	3.8	3.7	3.9	3.6	4.4	4.9	6.5
2 hr	3	3.6	3.8	3.7	3.9	3.6	4.3	4.9	6.5
6 hr	3	3.4	3.6	3.5	3.7	3.4	4.0	4.4	5.4
12 hr	3	3.3	3.4	3.4	3.5	3.3	3.7	4.0	4.7
24 hr	3	3.2	3.3	3.3	3.4	3.2	3.5	3.7	4.2
10 min	6	7.3	7.7	7.6	8.0	7.3	9.0	10	14
20 min	6	7.4	7.8	7.7	8.1	7.4	9.2	11	15
30 min	6	7.5	7.9	7.7	8.2	7.5	9.3	11	15
1 hr	6	7.5	8.0	7.8	8.3	7.5	9.5	11	16
2 hr	6	7.5	8.0	7.8	8.3	7.5	9.6	11	16
6 hr	6	7.2	7.5	7.4	7.8	7.2	8.7	9.9	13
12 hr	6	6.9	7.2	7.1	7.4	6.9	8.1	9.0	[illegible]
24 hr	6	6.7	6.9	6.8	7.1	6.7	7.6	8.2	9.8

Find new target ARI for current rainfall data


62SKRI Simulated Overflow Events (Base 10yr LTS scenario) - ARI assessment
Volume (m³)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.1
1.0
10.0
ARI (yr)
Base scenario
1,500m³ future-proofed design
400m³ volume required to contain spill
0.5yr Target containment standard
1.3yr Adjusted target
Key assumption: The ARI of overflows is impacted the same way as the ARI of rainfall events

Findings

- Documented for Wellington Water
- To enable consideration of climate-change adjusted target Average Recurrence Intervals for future levels of service for spills of untreated wastewater from Wellington Water's wastewater networks


NIWA
Taihoro Nukurangi

Climate changes effect on sub-annual rainfall return periods

Prepared for Wellington Water

May 2022

Climate, Freshwater & Ocean Science

Findings

- This report provides estimates of how rainfall return periods, for a range of durations, will change under different future climate scenarios…

Table 4 contains equivalent current climate return periods for the Wellington Region for a range of future climate return periods and scenarios. These have been estimated from monthly maxima data from each gauge record using the first (GEV-based) method described above before the weighted mean of all sites was taken to provide a regional average. For completeness, tables containing the values obtained from each rainfall gauges are provided in Appendix A.

An example application of the results in Table 4 might be as follows, assuming RCP 6.0 is considered most appropriate. If a wastewater network upgrade is required in the Wellington Region that is targeted to meet a 12-month “containment standard” over a time horizon up to 2050, then this should be designed to meet the 16-month “containment standard” under current rainfall conditions, adopting a nominal 1-hour response duration (see highlighted cell). The implication is that a containment standard of 16 months under current rainfall is predicted to still meet a 12-month containment standard in about 2050, assuming RCP 6.0 projections for this example.

Table 4: Wellington Regional average equivalent current climate return. Return periods shown in months for a range of expected return periods during different emissions scenarios and future time periods

Duration	Target Return Period	Equivalent Current Climate Return Period							
		2031-2050				2081-2100			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10 min	3	3.5	3.7	3.6	3.8	3.5	4.2	4.7	6.0
20 min	3	3.6	3.7	3.7	3.8	3.6	4.3	4.8	6.2
30 min	3	3.6	3.7	3.7	3.9	3.6	4.3	4.9	6.3
1 hr	3	3.6	3.8	3.7	3.9	3.6	4.4	4.9	6.5
2 hr	3	3.6	3.8	3.7	3.9	3.6	4.3	4.9	6.5
6 hr	3	3.4	3.6	3.5	3.7	3.4	4.0	4.4	5.4
12 hr	3	3.3	3.4	3.4	3.5	3.3	3.7	4.0	4.7
24 hr	3	3.2	3.3	3.3	3.4	3.2	3.5	3.7	4.2
10 min	6	7.3	7.7	7.6	8.0	7.3	9.0	10	14
20 min	6	7.4	7.8	7.7	8.1	7.4	9.2	11	15
30 min	6	7.5	7.9	7.7	8.2	7.5	9.3	11	15
1 hr	6	7.5	8.0	7.8	8.3	7.5	9.5	11	16
2 hr	6	7.5	8.0	7.8	8.3	7.5	9.6	11	16
6 hr	6	7.2	7.5	7.4	7.8	7.2	8.7	9.9	13
12 hr	6	6.9	7.2	7.1	7.4	6.9	8.1	9.0	11
24 hr	6	6.7	6.9	6.8	7.1	6.7	7.6	8.2	9.8
10 min	9	11	12	12	12	11	14	16	22
20 min	9	11	12	12	13	11	14	17	24
30 min	9	11	12	12	13	11	15	17	24
1 hr	9	12	12	12	13	12	15	18	26
2 hr	9	12	12	12	13	12	15	18	27
6 hr	9	11	12	11	12	11	14	16	22
12 hr	9	11	11	11	11	11	13	14	19
24 hr	9	[illegible]	[illegible]	10	11	10	12	13	16

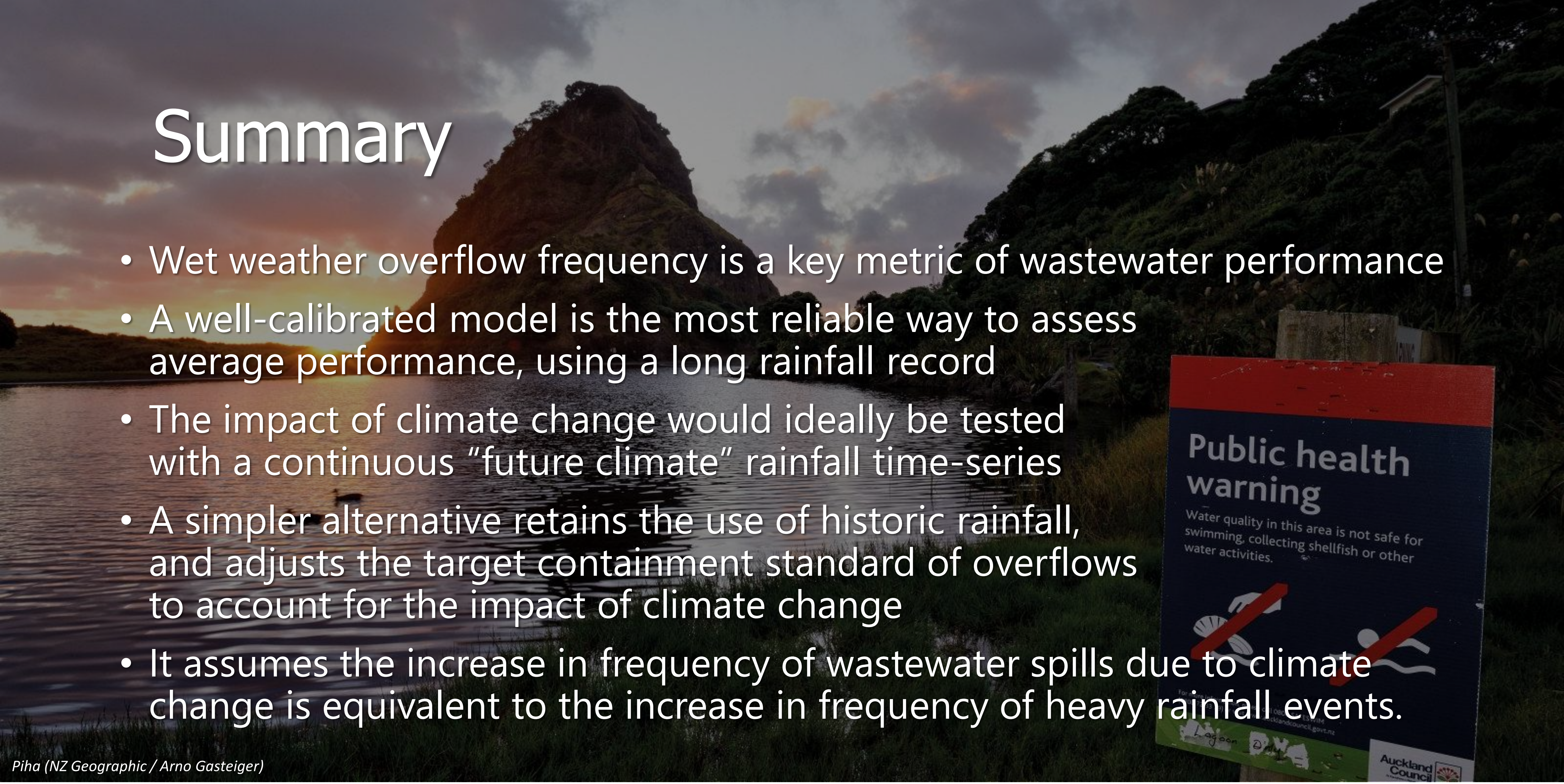
Findings

- …in the form of Wellington Region average equivalent current climate return periods associated with selected future return periods.

Duration	Target Return Period	Equivalent Current Climate Return Period							
		2031-2050				2081-2100			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10 min	12	15	16	16	17	15	19	22	32
20 min	12	15	16	16	17	15	20	23	33
30 min	12	15	16	16	17	15	20	24	34
1 hr	12	16	17	16	18	16	21	25	37
2 hr	12	16	17	16	18	16	21	25	38
6 hr	12	15	16	16	17	15	19	22	32
12 hr	12	14	15	15	16	14	17	20	27
24 hr	12	14	14	14	15	14	16	18	22
10 min	18	23	25	24	26	23	30	35	50
20 min	18	23	25	24	26	23	30	36	53
30 min	18	24	25	25	26	24	31	37	55
1 hr	18	24	26	25	27	24	32	39	59
2 hr	18	24	26	25	28	24	33	40	64
6 hr	18	23	25	24	26	23	30	36	53
12 hr	18	22	23	23	24	22	27	31	43
24 hr	18	21	22	21	22	21	25	27	35
10 min	24	31	33	32	35	31	40	48	70
20 min	24	32	34	33	36	32	42	50	75
30 min	24	32	34	33	36	32	42	51	77
1 hr	24	32	35	34	37	32	44	54	84
2 hr	24	33	36	35	38	33	46	57	92
6 hr	24	31	34	33	35	31	42	50	77
12 hr	24	30	32	31	33	30	38	44	62
24 hr	24	28	30	29	31	28	34	38	50
10 min	36	47	51	49	53	47	63	75	110
20 min	36	48	52	50	55	48	65	79	120
30 min	36	49	52	51	55	49	66	81	120
1 hr	36	50	54	52	57	50	69	85	140
2 hr	36	51	55	53	59	51	72	91	150
6 hr	36	48	52	51	55	48	66	81	130
12 hr	36	46	49	48	51	46	59	70	100
24 hr	36	43	45	45	47	43	53	60	79

Summary

- Wet weather overflow frequency is a key metric of wastewater performance
- A well-calibrated model is the most reliable way to assess average performance, using a long rainfall record
- The impact of climate change would ideally be tested with a continuous "future climate" rainfall time-series
- A simpler alternative retains the use of historic rainfall, and adjusts the target containment standard of overflows to account for the impact of climate change
- It assumes the increase in frequency of wastewater spills due to climate change is equivalent to the increase in frequency of heavy rainfall events.



Piha (NZ Geographic / Arno Gasteiger)

Acknowledgements

- Trevor Carey-Smith (NIWA)
- Alistair Osborne (Wellington Water)
- Nadia Nitsche (Wellington Water)
- Tim Lockie (Hydraulic Analsis Ltd)
- Nathan Shaw (Hydraulic Analysis Ltd)

Piha (NZ Geographic / Arno Gasteiger)

Modelling Group
WATER NEW ZEALAND

Modelling Symposium

Thank you!
Questions? Patai?

HAL HYDRAULIC ANALYSIS LIMITED

water NEW ZEALAND
The New Zealand Water & Wastes Association Waiora Aotearoa