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Hydrological Modelling Dataset

Report 2a: 2021 HMD Flow Series Comparison with 2018

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150 YEARS IN AOTEAROA

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This report ('**Report**') has been prepared by WSP exclusively for the Electricity Authority ('**Client**') in relation to Hydrological Modelling Dataset 2021 Full Update ('**Purpose**') and in accordance with the AoG Consultancy Service Order (CSO) dated 17 March 2021. The findings in this Report are based on and are subject to the assumptions specified in the Report and CSO dated 17 March 2021. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

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Preface

A large proportion of New Zealand's electricity needs are met by generation from hydro power. Information about the distribution of inflows and the capability of the various hydro systems is necessary to ensure a reliable, competitive and efficient market and electricity system.

The hydrological modelling dataset (HMD) is a dataset of hydrological information made available by the Electricity Authority. The dataset was known as the SPECTRA update until 2010. In 2015 the dataset was revised to become the HMD, a comprehensive dataset that can be relied upon by modellers and analysts to test scenarios, provide commentary and inform decisions.

The HMD is comprised of data provided by hydro generators and supplemented with some from other sources. These parties are acknowledged for their contribution and for making this data available.

The HMD consists of three main components:

1. Infrastructure and hydrological constraint attributes:

   This dataset records standing information about the capability of the main hydro schemes.
2. Flows:

   This time series dataset records data for inflows for reservoirs and flows at various existing or potential hydro generating sites.
3. Storage and spill:

   This time series dataset records storage for the main hydro schemes.

This report describes the differences between the 2018 HMD flow series data and the 2021 HMD flow series data.

Contents

1 Introduction

1.1 Datasets and mean flows

Care is taken to ensure consistency of data between successive HMD updates. A comparison of the mean flows for each flow series is listed in Table 1-1 for the North Island and Table 1-2 for the South Island.

Table 1-1: North Island flow dataset names and mean values derived from the previous HMD update (2018) and this HMD update (2021).

Flow	Model flow name	Flow site number	Mean flow (m^3/s)		Type
			1 Jan 1932 to 31 Dec 2017	1 Jan 1932 to 31 Dec 2020	
Arapuni Tribs	Arapuni	92724 (1)	81.39	81.49	A
Karapiro Tribs	Karapiro	92714 (1)	91.42	91.08	A
Tokaanu	TokaanuTPD	92790 (3)	52.54	52.39	A
Tokaanu	Toka_Linear	22790 (3)	53.48	53.24	A
Taupo	TaupoTPD	92790 (1)	155.88	155.45	A
Taupo	Taupo_Linear	22790 (1)	154.64	154.13	A
Taupo	Taupo_Actual	42790 (1)	139.90	139.91	A
Taupo	Taupo_Infrastructure	72790 (1)	150.02	148.60	A
Taupo	Taupo_Natural	62790 (1)	125.91	125.55	N
Rangipo	RangipoTPD	92790 (2)	34.68	34.62	A
Rangipo	Rangi_linear	22790 (2)	28.81	28.8	A
Waikaremoana	Waikaremoana	3650 (1)	17.75	17.64	N+A
Matahina	Matahina	93254 (1)	64.51	64.40	A
Wheao	Wheao	15462(1)	12.88	12.82	A
Mangahao	Mangahao	97502(1)	8.70	8.70	A
Patea	Patea	34300(1)	19.38	19.55	A
Kaimai	Wairoa	14130(1)	11.87	11.86	A
Ngaruroro	Whanawhana	123103 (1)	35.12	34.97	N+A
	Kuripapango	123104 (1)	17.70	17.69	N+A
	Chesterhope	123150 (1)	43.68	43.64	N+A
Mohaka	Raupunga	121801 (1)	79.19	78.91	N+A

"N" denotes a natural flow, uncontrolled flow
"A" denotes an actual flow
"N+A" denotes a flow that is both actual and natural
(*) Denotes item number of historic Tideda file, data is now stored in Hilltop Manager and uses the primary number

Table 1-2: South Island flow dataset names and mean values derived from the previous HMD update (2018) and this HMD update (2021).

Flow	Model flow name	Flow site number	Mean flow (m^3/s)		Type
			1 Jan 1932 to 31 Dec 2017	1 Jan 1932 to 31 Dec 2020	
Waitaki P.S. Tribs	Waitaki	98714 (2)	152.03	149.60	A
Benmore	Benmore	98614 (4)	132.61	132.77	A
	Ben_tp	98615 (2)	123.42	123.41	A
Ohau (separate Tekapo model)	OhauRes	98614 (6)	70.33	70.39	A
	Ohau	98614 (3)	80.31	80.29	N+A
Pukaki	Pukaki	98614 (2)	195.20	195.59	A
Natural Pukaki	Nat_Puk	98770 (1)	126.24	126.52	N
Tekapo	Tekapo	98614 (1)	68.99	69.13	A
Natural Tekapo	Nat_Tek	98770 (2)	83.40	83.62	N+A
Manapouri	Manawmara	99551 (1)	137.27	137.07	A
	Manapouri	99550 (1)	122.31	122.14	N
	Manareduced	99552 (1)	121.11	125.78	A
Te Anau	Teanau	9570 (1)	283.16	284.48	N+A
Monowai	Mono_Inflow	199540 (1)	12.93	12.96	N+A
Roxburgh	Roxburgh	99110 (1)	444.78	446.64	A
Wanaka	Wanaka	9154 (1)	196.68	197.63	N+A
Hawea	Hawea	9170 (1)	64.53	64.47	N+A
Cobb	Cobb	97904 (2)	5.41	5.38	N+A
Coleridge	Coleridge	97904 (1)	24.72	24.77	A
Highbank	Highbank	7968(1)	13.40	13.48	A
Waipori	Waipori	174395(1)	7.40	7.41	A
Grey+Taramakau-Taipo	Grey_tara CLOSED	77106(1)	437.24	436.32	A
Grey+Taramakau-Taipo	Grey_tara	77106(2)	426.50	431.80	A
Waiau	Clarence	162105 (1)	14.46	14.41	N+A
	Glenhope	164604 (1)	33.81	33.63	N+A
	Marble Point	164602 (1)	94.03	93.78	N+A
Wairau	Dip Flat	160114 (1)	26.51	26.48	N+A
Hurunui	Mandamus	165104 (1)	51.20	51.12	N+A
	SH 1 Bridge	165101 (1)	66.21	66.21	N+A
Lake Onslow	Onslow	175237 (1)	-	5.40	N+A

"N" denotes a natural flow, uncontrolled flow
"A" denotes an actual flow
"N+A" denotes a flow that is both actual and natural
(*) Denotes item number of historic Tideda file, data is now stored in Hilltop Manager and uses the primary number
Lake Onslow is a new site and therefore was not in the previous update.

2 Data Differences for Calculated Flow Sites

Differences between datasets may occur from one update to the next because of rating changes, data modifications, inflows being recalculated, and various other reasons. Table 2-1 shows if there were any differences in the data between the previous and current updates for North Island flow

sites and Table 2-2 shows if there were any differences for South Island flow sites. The following sections highlight the reasons for these differences.

At the time of this update, Trustpower had not provided the entire data series required for a comparison report; therefore, no comparison could be made with the 2018 update datasets and have been excluded from this comparison report; i.e. they have only provided new data from 2018.

Table 2-1: Data differences for previous and current updates for North Island flow sites.

Flow site number and item number	Flow site name	Data differs
92724 (1)	Arapuni Tributary inflows	Y
92714 (1)	Karapiro Tributary inflows	Y
22790 (1)	Taupo linear Inflows	N
22790 (2)	Rangipo linear Inflows	Y
22790 (3)	Tokaanu linear Inflows	Y
92790 (1)	Taupo non-linear Inflows	Y
92790 (2)	Rangipo non-linear Inflows	Y
92790 (3)	Tokaanu non-linear Inflows	Y
42790 (1)	Taupo operational inflows	Y
72790 (1)	Taupo infrastructure inflows	Y
62790 (1)	Taupo natural inflows	Y
3650 (1)	Waikaremoana inflows	Y
93254 (1)	Matahina Outflows	Y
15462 (1)	Wheao/Flaxy Outflows	Y
97502 (1)	Mangahao Inflows	N
34300 (1)	Patea Outflows	Y
14130 (1)	Kaimai Outflows at Ruahihi	Y
123103 (1)	Ngaruroro - Whanawhana	Y
123104 (1)	Ngaruroro - Kuripapango	Y
123150 (1)	Ngaruroro - Chesterhope	Y
121801 (1)	Mohaka - Raupunga	N

Table 2-2: Data differences for previous and current updates for South Island flow sites.

Flow site number and item number	Flow site name	Data differs
98714 (2)	Waitaki Tributaries (Benmore)	Y
98614 (4)	Benmore Tributary Flows	Y
98615 (2)	Benmore_tp	Y
98614 (6)	Ohau Residual Flows	N
98614 (3)	Ohau (Ohau B and C)	N
98614 (2)	Pukaki	Y
98770 (1)	Pukaki natural inflows	Y
98614 (1)	Tekapo	Y
98770 (2)	Tekapo natural inflows	Y
99550 (1)	Manapouri local inflow (no Mararoa)	Y
99551 (1)	Manapouri local inflow (incl. Mararoa)	Y
99552 (1)	Manapouri local inflow (no Mararoa + water right reduction)	Y
9570 (1)	Lake Te Anau inflow	Y
199540 (1)	Monowai Inflow	Y
99110 (1)	Roxburgh tributary flows	Y
9154 (1)	Wanaka Outflow	Y
9170 (1)	Hawea Inflow	Y
97904 (2)	Cobb Inflow	Y
97904 (1)	Coleridge Inflow	Y
7968 (1)	Highbank Outflows	Y
174395 (1)	Waipori Outflows	Y
77106 (1)	Grey + Taramakau - Taipo	Y
162105 (1)	Waiau - Jollies	N
164604 (1)	Waiau - Glenhope	Y
164602 (1)	Waiau - Marble Point	Y
160114 (1)	Wairau - Dip Flat	Y
165104 (1)	Hurunui - Mandamus	Y
165101 (1)	Hurunui - SH1 Bridge	Y
175237 (1)	Lake Onslow inflows	-

3 North Island Flow Sites

Many sites exhibit minor differences compared to the last HMD full update (2018). This is due to the majority of the Tideda scripts being converted into Hilltop Manager 'VSim' scripts, as Tideda is no longer used by many of the local recording authorities. The new software averages the data slightly differently as it can 'store' the entire number, rather than 'rounding' it like Tideda was required to. This has resulted in mainly differences in the mean and median statistics, but not significantly to the overall dataset that it would impact detailed analysis.

3.1 92724 (1) Arapuni Tributaries

There are very minor differences for the Arapuni Tributaries dataset, as evident by very similar summary statistics displayed in Table 3-1. The 'raw' input sites have not changed; the differences are attributed to a change in script software processing but should not impact detailed analysis of the datasets.

Table 3-1: Arapuni tributaries (92724 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.00	81.31	77.02	636.28
2018	0.00	81.39	77.27	636.28

3.2 92714 (1) Karapiro Tributaries

There is a period of significant change from February 1961 to November 1961 between the two datasets, as new recalculated data was provided for this time period. The difference has not significantly altered the summary statistics of the site, as displayed in Table 3-2.

Table 3-2: Karapiro tributaries (92714 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.00	91.33	86.31	572.34
2018	0.00	91.42	86.62	572.34

3.3 22790 (1) Taupo Inflow Linear

There are no differences between the two datasets derived from the previous update to this one, as evident in Table 3-3.

Table 3-3: Taupo Inflow Linear (22790 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	23.76	154.64	134.85	1489.29
2018	23.76	154.64	134.85	1489.29

3.4 22790 (2) Rangipo Linear

The differences in the Taupo Linear series start from April 1987 to the present. This is because Genesis Energy provided new datasets for the input sites (Waihohonu at Desert Rd, and Wairehu Canal at Gauging Br), as there was review of the ratings for the site which resulted in a change. This only impacts data from 1987 to the present as the datasets are subtracted from the Taupo Inflows series, which has not been altered. This has impacted the entire dataset, although has not changed the overall median and minimum flows, as shown in Table 3-4.

Table 3-4: Rangipo Linear (22790 (2)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.00	28.88	26.19	90.69
2018	0.00	28.81	26.19	92.96

3.5 22790 (3) Tokaanu Linear

There are minor differences in the Taupo Linear series start from April 1987 to the present. This is because Genesis Energy provided a new dataset for Wairehu Canal at Gauging Br, which is used as an input site, as there was a review of the ratings for the site which resulted in a change. This only impacts data from 1987 to the present at small, discrete locations, as the data are subtracted from the Taupo Inflows series, which has not been altered. Because of the constraints of this dataset, it

has not impacted the minimum or maximum flows, and overall has not drastically altered the mean or median flows as shown in Table 3-5.

Table 3-5: Tokaanu Linear (22790) (3)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	7.99	53.47	47.75	226.12
2018	7.99	53.48	47.75	226.12

3.6 92790 (1) Taupo

The main input to the HMD Taupo Inflows dataset (92790 (1)) is the Taupo Natural Inflows series (62790). A key input into the natural inflows series is the Tongariro Power Diversion Foreign Inflows (TPD Inflows) dataset. This is provided by Genesis Energy. New data was provided in the 2020 update from October 1979. This has resulted in differences for all datasets that use Taupo Natural Inflows as an input, specifically all 92790 non-linear datasets. This is evident when comparing the summary statistics for the site in Table 3-6, however it has not significantly altered the mean and median statistics.

Table 3-6: Taupo non-linear (92790 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.47	155.95	135.90	1426.67
2018	0.47	155.89	135.84	1426.67

3.7 92790 (2) Rangipo

Similar to the Taupo Inflows dataset (92790 (1)), the main input to the HMD Rangipo Inflows dataset (92790 (2)) is a Taupo Natural Inflows series. A key input into the natural inflows series is the Tongariro Power Diversion Foreign Inflows (TPD Inflows) dataset. This is provided by Genesis Energy. New data was provided in the 2020 update from October 1979. This has resulted in differences for all datasets that use Taupo Natural Inflows as an input, specifically all 92790 non-linear datasets. The differences have not significantly impacted the summary statistics for the site, as evident in Table 3-7, because of the flow conditions have not been altered as per the consent conditions for this dataset.

Table 3-7: Rangipo non-linear (92790 (2)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.00	34.70	32.40	63.00
2018	0.00	34.68	32.38	63.00

3.8 92790 (3) Tokaanu

Similar to the Taupo Inflows dataset (92790 (1)), the main input to the HMD Tokaanu Inflows dataset (92790 (3)) is a Taupo Natural Inflows series. A key input into the natural inflows series is the Tongariro Power Diversion Foreign Inflows (TPD Inflows) dataset. This is provided by Genesis Energy. New data was provided in the 2020 update from October 1979. This has resulted in differences for all datasets that use Taupo Natural Inflows as an input, specifically all 92790 non-linear datasets.

The differences have not significantly impacted the summary statistics for the site, as evident in Table 3-8.

Table 3-8: Tokaanu non-linear (92790 (3)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.00	52.58	47.62	158.91
2018	0.00	52.54	47.59	158.91

3.9 42790 Taupo Actual Inflows

The Taupo Actual Inflows dataset is an inflow series that is provided by Mercury. In 2012 the dataset was recalculated based on new MW rating curves provided by Mercury for the Taupo Inflows series. However, the corrected data was not included in the output file in the 2018 update, though was incorporated in correlating and extending multiple flow records back to 1932. Therefore, the differences represent the change in the MW rating curves, as evident by the small differences in the summary statistics in Table 3-9. This has resulted in a lower median and maximum value in the dataset when using the corrected rating curve.

Table 3-9: Taupo actual inflows (42790 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	2.00	139.90	121.02	1357.00
2018	2.00	139.90	120.69	1357.31

3.10 62790 Taupo Natural Inflows

Taupo Natural Inflows was a new dataset requested by the EA during the 2018 full HMD update. Refer to Report 2 for details of how this dataset is created. New data provided by Genesis for the TPD inflows, a key data input into this site, resulted in minor changes from October 1979. This has resulted in the observed differences from this date onwards, as evident in Table 3-10.

Table 3-10: Taupo natural inflows (62790 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.00	125.96	107.08	1357.31
2018	0.00	125.91	106.88	1357.31

3.11 72790 Taupo Infrastructure Inflows

The Taupo Infrastructure Inflows was a new dataset requested by the EA during the 2018 full HMD update. Refer to Report 2 for details of how this dataset is created. New data provided by Genesis for the TPD inflows compared to recent Actual Taupo Inflows resulted in a change in the correlated relationship. This correlation equation was updated and back dated to 1932. This has resulted in differences, including to the minimum and maximum flow statistics for this site, as evident in Table 3-11.

Table 3-11: Taupo infrastructure inflows (72790 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.00	148.90	130.09	1431.68
2018	2.00	150.02	131.15	1433.74

3.12 3650 (1) Waikaremoana

There were minor differences in the data provided by Genesis between the 2018 and 2020 updates, specifically around gap filling of the data. Additionally, any negative values have been zeroed as requested by the Electricity Authority. This has resulted in a change to the mean average inflows as shown in Table 3-12.

Table 3-12: Waikaremoana (3650 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.00	17.70	11.05	686.14
2018	0.00	17.75	11.05	686.14

3.13 123103 (1) Ngaruroro - Whanawhana

There are very small differences in this dataset from rating additions and changes that have come from NIWA from 1963 to the end of 2014, mainly from a rating change in 2017, as evident in Table 3-13. The changes are of a small magnitude; differences range from +/-1m^3/s on average.

Table 3-13: Ngaruroro at Whanawhana (123103 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	1.40	35.13	25.86	837.36
2018	1.40	35.12	26.86	837.36

3.14 123104 (1) Ngaruroro - Kuripapango

There are very small differences in this dataset from rating additions and changes that have come from NIWA from 1963 to the end of 2014 as evident in Table 3-14. A main rating change in 2016 has resulted in a shift of the overall mean. The changes are of a small magnitude; differences range from +/-1m^3/s on average.

Table 3-14: Ngaruroro at Kuripapango (123104 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.85	17.72	12.66	385.09
2018	0.85	17.70	12.66	385.09

3.15 123150 (1) Ngaruroro - Chesterhope

There are very small differences in this dataset from rating additions and changes that are from NIWA (Table 3-15). The changes are of a small magnitude; differences range from +/-1m^3/s on average, but has caused a change in the maximum peak flow.

Table 3-15: Ngaruroro at Chesterhope (123150 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	1.00	43.68	28.02	1698.97
2018	1.00	43.68	28.02	1699.38

3.16 121801 (1) Mohaka - Raupunga

There are no differences in this dataset from HBRC (Table 3-16).

Table 3-16: Mohaka (121801 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	13.25	79.19	59.92	1619.11
2018	15.25	79.19	59.92	1619.11

3.17 97502 (1) Mangahao

This update the spill ratings, gate positions and lake level for No.2 Dam were provided to derive the spill flow from, along with the generation data; no historical data was provided. Therefore, there are no differences to the datasets where they overlap, unlike previous years (Table 3-17).

Table 3-17: Mangahao Inflows (97502 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.00	8.70	6.34	320.11
2018	0.00	8.70	6.34	320.11

4 South Island Flow Sites

4.1 98714 (2) Waitaki Tributaries

There are multiple differences for the entire dataset. Alterations to the Tekapo Spill, Tekapo A. and Tekapo B discharge datasets, which are all inputs used in the creation of the Waitaki Tributaries, by Genesis resulted in minor differences for this dataset to the present as shown in Table 4-1. Additionally, larger differences occur from 1965 due to a review of the Waitaki spillway weir rating, which has caused a large change in the maximum flow value.

Table 4-1: Waitaki tributaries (98714 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.00	149.31	131.80	1441.52
2018	0.00	152.03	132.34	1567.68

4.2 98614 (4) Benmore Tributary Flows

There are differences in this file that stem from new Tekapo inflows that were provided by Genesis Energy correlated back to 1932. Furthermore, there were changes to the ratings for Ahuriri at South Diadem, which is an input site into the Benmore tributary model. These changes impacted the mean, median and maximum flows for this dataset as shown in Table 4-2.

Table 4-2: Benmore tributaries (98614 (4)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	7.66	132.62	98.66	2962.93
2018	7.66	132.61	98.65	2791.82

4.3 98615 (2) Benmore_tp

There are differences between the full updates for this dataset because of rating changes to Ahuriri at South Diadem and Ahuriri at Benmore, a historic site, by NIWA. This has altered all but the minimum flows, as evident in Table 4-3.

Table 4-3: Benmore tributaries (98615 (5)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	7.66	123.35	98.51	2019.61
2018	7.66	123.42	98.11	2312.92

4.4 98614 (2) Pukaki

There are differences in this file that stem from new Tekapo inflows that were provided by Genesis Energy correlated back to 1932. As this is an input file in the Pukaki calculation, this has resulted in minor differences for the dataset, as shown in Table 4-4, although has not changed the maximum value.

Table 4-4: Pukaki (98614 (2)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.00	195.25	162.01	2829.44
2018	0.00	195.20	162.09	2829.44

4.5 98614 (1) Tekapo

There are differences in this file that stem from new Tekapo inflows that were provided by Genesis Energy correlated back to 1932. This has resulted in minor differences for the dataset, specifically from 1966 onwards, as shown in Table 4-5.

Table 4-5: Tekapo (98614 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	4.48	68.97	61.46	130.00
2018	4.48	68.99	61.48	130.00

4.6 98770 (2) Tekapo Naturals

There are minor differences in this file that stem from new Tekapo inflows that were provided by Genesis Energy correlated back to 1932. This required recalculation of the Tekapo Natural inflows, which explains the differences observed in Table 4-6, although it did not impact the minimum or maximum values.

Table 4-6: Tekapo Natural (98770 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.03	83.43	66.66	1175.35
2018	0.03	83.40	66.64	1175.35

4.7 98770 (1) Pukaki Naturals

There are minor differences from the early 1990s to 200s because of alterations to Tekapo B Discharge, which is provided by Genesis Energy. This has resulted in a slight change to the summary statistics for the site, as shown in Table 4-7. Otherwise the dataset remains unchanged.

Table 4-7: Pukaki Naturals (98770 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.00	126.33	98.06	2699.44
2018	0.00	126.25	97.98	2699.44

4.8 99550 (1) Manapouri local inflow (no Mararoa)

There are differences from September 1969 in the dataset, due to changes in the raw input sites, which affects the Mararoa data series. Specifically, there has been rating updates across the entire Mararoa flow site, which alters the daily flow values to varying degree (Table 4-8). This has resulted in a significant change to the peak flow for this dataset.

Table 4-8: Manapouri local inflow (99550 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.00	122.13	77.97	2313.26
2018	0.00	122.31	79.00	2099.07

4.9 99551 (1) Manapouri local inflow (incl. Mararoa)

There are differences from September 1969 in the dataset, due to changes in the raw input sites, which affects the Mararoa data series. Specifically, there has been rating updates across the entire Mararoa flow site, which alters the daily flow values to varying degree (Table 4-9). Additionally, during the conversion from the Tideda script to VSim in Hilltop Manager, the script was updated to 'zero' the data when it would go negative, to reflect what the local inflow could be (i.e. zero, not negative).

Table 4-9: Manapouri local inflow (99551 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.00	137.03	96.12	2313.26
2018	-99.65	137.20	97.66	2099.07

4.10 99552 (1) Manapouri local inflow (no Mararoa + water right reduction)

There are differences from September 1969 in the dataset, due to changes in the raw input sites, which affects the Mararoa data series. Specifically, there has been rating updates across the entire Mararoa flow site, which alters the daily flow values to varying degree (Table 4-10). Additionally, during the conversion from the Tideda script to VSim in Hilltop Manager, the script was updated to

'zero' the data when it would go negative, to reflect what the local inflow could be (i.e. zero, not negative).

Table 4-10: Manapouri local inflow (99552 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.00	125.74	83.63	2532.31
2018	-99.65	121.11	81.48	2099.07

4.11 199540 (1) Monowai inflows

There are very minor differences for the Monowai inflow series as there have been rating changes from May 1977 to the dataset (Table 4-11). However, it has not changed the overall minimum and maximum values, just the mean.

Table 4-11: Monowai (199540 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.00	12.94	8.56	251.80
2018	0.00	12.93	8.56	251.80

4.12 99110 (1) Roxburgh tributary flows

There are differences to this data series because of entire rating changes to Hawea River at Camphill Bridge, one of the input flow sites. These changes occurred from September 1971, which has changed the overall statistics for this site (Table 4-12).

Table 4-12: Roxburgh (99110 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.00	445.16	400.05	3314.97
2018	2.84	444.78	399.51	3315.37

4.13 77106 (1) Grey + Taramakau – Taipo (closed)

This site is no longer newly created, as two of the input sites (Taipo River and Taramakau River) have been closed by NIWA. However, the last ratings have been updated from the last update, resulting in differences. This has had a minor impact on the overall statistics for the site (Table 4-13).

Table 4-13: Grey River (77106 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	42.00	436.32	325.19	7740.00
2018	42.03	437.24	320.28	7740.43

4.14 77106 (2) Grey + Taramakau - Taipo

There are differences between the two datasets. This is because Grey River at Dobson, the main flow site, had large rating changes, which changed the overall correlation relationship. This was back calculated to 1932, resulting in differences across the entire dataset. (Table 4-14).

Table 4-14: Grey River (77106 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	40.77	432.11	326.02	7641.40
2018	45.45	426.51	309.74	7257.61

4.15 162105 (1) Waiau - Jollies

There are no changes as the ratings have not changed since the last update (Table 4-15).

Table 4-15: Waiau at Jollies (162105 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	1.71	14.46	10.73	405.65
2018	1.71	14.46	10.73	405.65

4.16 164604 (1) Waiau – Glenhope

There are differences in the data due to changes in ratings at the correlated site. As this site is no longer rated, but there were new ratings applied to the correlated site, a new relationship was established between this site and Waiau at Marble Point where the measured flow data overlaps. This new correlation was then back-calculated to 1932 and to the present. This new correlation used audited data that has undergone modification since the last update, and therefore explains the observed differences in the dataset, as shown in Table 4-16, notably at the top and bottom end of the flow spectrum.

Table 4-16: Waiau at Glenhope (164604 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	5.82	33.75	26.50	582.89
2018	6.60	33.81	26.37	582.84

4.17 164602 (1) Waiau - Marble Point

There are minor differences in this dataset dating back to 1971, due to rating changes at the site in the mid-range. This has had a minor impact on the overall statistics for the site but has not changed the peak or minimum flows (Table 4-17).

Table 4-17: Waiau at Marble Point (164602 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	19.48	94.15	72.92	1578.58
2018	19.48	94.03	72.86	1578.58

4.18 160114 (1) Wairau – Dip Flat

There are very small differences in this dataset, due to slight changes to the ratings at the site, which has slightly altered the median flow (Table 4-18). However, these changes are practically unnoticeable.

Table 4-18: Waiau at Dip Flat (160114 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	4.01	26.51	20.29	587.88
2018	4.01	26.51	20.28	587.88

4.19 165104 (1) Hurunui – Mandamus

There are very small differences in this dataset, due to slight changes to the ratings at the site, which has slightly altered the mean flow (Table 4-19). However, these changes are practically unnoticeable.

Table 4-19: Hurunui at Mandamus (165104 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	7.91	51.18	39.35	1066.08
2018	7.91	51.21	39.35	1066.08

4.20 165101 (1) Hurunui – SH1 Bridge

There are small differences in this dataset, due to changes in the ratings, noticeably at the lower end i.e. minimum flows. This has had a minor impact on the statistics for the site, but has not changed the peak discharge (Table 4-20).

Table 4-20: Hurunui at SH1 Bridge (165101 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	7.00	66.32	51.84	1827.52
2018	9.67	66.21	51.91	1827.52

4.21 9154 (1) Lake Wanaka

There are small differences in this dataset, due to the data provided by NIWA being very slightly different (both water level and tweaks to the rating). This has only changed the mean and median statistics, the minimum and maximum remain unchanged (Table 4-21).

Table 4-21: Lake Wanaka (9154 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	38.71	196.77	175.77	1414.18
2018	38.71	196.68	175.68	1414.18

4.22 9170 (1) Lake Hawea

There are significant differences to the Lake Hawea Inflow series from 1971. This is because the inflow series is derived from the total outflow series from Lake Hawea. The outflow ratings have changed, and therefore the entire outflow and subsequent inflow record has changed from this point forward, impacting the entire dataset statistics (Table 4-22).

Table 4-22: Lake Hawea (9170 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.84	64.38	47.57	1648.20
2018	2.00	64.53	47.70	1633.93

4.23 9570 (1) Lake Te Anau

There are only minor differences to the Te Anau Inflow series, as data was recalculated from 2016 following rating changes to Wairau at Queens Reach, a key flow site in the total outflows, and therefore inflows, into Lake Te Anau. This had a minor impact on the overall statistics for the site (Table 4-23).

Table 4-23: Lake Te Anau (9570 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	0.03	283.31	184.22	4830.50
2018	0.03	283.15	184.03	4830.50

4.24 98614 (1) Ohau Inflows

There were very few erroneous differences in the dataset which have not impacted the overall statistics for this site (Table 4-24).

Table 4-24: Ohau Inflows (98614 (1)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	2.00	80.31	63.38	1605.93
2018	2.00	80.31	63.38	1605.93

4.25 98614 (2) Ohau Residual Inflows

There were very few erroneous differences in the dataset which have not impacted the overall statistics for this site (Table 4-25).

Table 4-25: Ohau Residual Inflows (98614 (2)) data difference table.

Update year	Minimum (m^3/s)	Mean (m^3/s)	Median (m^3/s)	Maximum (m^3/s)
2021	-10.00	70.33	52.99	1593.93
2018	-10.00	70.33	52.99	1593.93

5 Negative Flows in Datasets

The HMD series are derived to indicate potential generation. Therefore, a negative value implies that there is no water for generation. Negative data cannot exist as this implies that water is being lost from the system. Therefore, although a negative data value is not incorrect it shows that there is no water available for generation.

The following four flow sites have negative flows in their dataset.

- Lake Waikaremoana - 3650: Waikaremoana inflows has negatives because of leakage from Lake Waikaremoana. Opus who previously calculated Waikaremoana inflows on behalf of

Genesis, had a minimum inflow value to ensure that no negative inflows were calculated. Genesis prefers negative inflows in the data until a solution can be found to quantify and resolve lake leakage. For the purposes of this update, the negatives have been zeroed at the request of the Electricity Authority.

- OhauRes - 98614(6): This dataset has negative data values when the inflow to Lake Ohau drops below the required residual consent flow of 8m³/s for 1 May to 31 October and 12m³/s for 1 November to 30 April.
- Manareduced - 99552: This dataset simulates the effects of minimum flow regimes, Mararoa dirty water spill, and flushing and recreational flows. Historically, the dataset had negative values if the inflow to Lake Manapouri was less than the required 150m³/s flushing and recreational consent flows. In some instances when the Mararoa was in flood, and the spill of dirty water was required (when flow was greater than 40m³/s), inflows to Manapouri were less than outflows resulting in negative water because of the outflows timing issues. In this update, negative flows were removed as they are physically inconsistent (i.e., negative flows do not exist in reality).
- Manawmara - 99551: This dataset only simulates the effects of dirty water flows. In some instances, when the Mararoa is in flood and the spill of dirty water is required (if the flow is greater than 40m³/s), inflows to Manapouri were less than outflows resulting in negative water because of the outflows timing issues. In this update, negative flows were removed as they are physically inconsistent (i.e., negative flows do not exist in reality).

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