Journal of Hydrology (NZ) 37(1): 1-17, 1998

Changes to New Zealand's national hydrometric network in the 1990s

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Abstract

In New Zealand, hydrometric data have been collected since the early 1900s; by the early 1990s more than 500 water-level recorders were operating, run either centrally by the National Institute of Water and Atmospheric Research (NIWA) as the National Hydrometric Network (290 stations) or as local networks by regional and district councils. In 1993, the government reduced funding for the National Hydrometric Network by 20%, necessitating a reduction of the network. This paper describes the principles and methods used to re-design the network, and their implications for users of hydrological data. Further changes to the network may be needed in the future – research on optimum network designs using information such as flow variability is outlined.

Introduction

Hydrological networks are designed to gather information on the quantity and quality of water moving through catchments and along rivers. The most common type of network is a set of water-level recorders: their records, together with flow gaugings, provide time series of river flow for each catchment within a region. Other hydrological networks include instruments for measuring rainfall, evaporation, soil moisture and groundwater physical processes; some networks are also used to monitor water quality (e.g. Smith and McBride, 1990; Smith *et al.*, 1996) and instream ecology.

This paper describes changes to New Zealand's national river flow network necessitated by funding cuts during the 1990s. There are two main sections of the paper: a chronology of changes in the network's structure and research on network-design. The history of water-level and streamflow recording in New Zealand is presented up to the 1990s, when one major reduction (1993/94) and one minor re-design (1996) of the

National Hydrometric Network were carried out. The future of the network and its interaction with other networks are discussed, including network-design research using information on flow variability.

Network structure

Up to the early 1990s

New Zealand's hydrometric data collection began in the early 1900s, when lake levels began to be monitored for hydro-electric potential. Major rivers of regional importance were monitored regularly from the 1930s. During the International Hydrological Decade (1965-74) monitoring started at over 50 of 90 "representative" river catchments (Toebes and Palmer, 1969; Toebes and Ouryvaev, 1970). This number of stations was necessary because of the extraordinary range of hydrological conditions encountered in New Zealand. In the South Island, for example, rainfall on the western slopes of the Southern Alps, a southwest-northeast chain of mountains 600 km long and typically 2500 m high, exceeds 10 m per year. Rainfall is less than 0.4 m per year in the driest rain shadow areas, less than 100 km east of the Alps. In the central North Island, mantles of volcanic ash create unusually porous conditions within some catchments.

The representative water-level recording stations were operated primarily by the Ministry of Works and Development, with hydrological field teams located at 16 centres around New Zealand; stations were also run by regional water boards. Mosley and McKerchar (1989) give a history of the legislative background and operation of New Zealand's water-level and flow recording network, up to the end of the 1980s. A National Hydrometric Reference Network (Duncan, 1986; Mosley and McKerchar, 1989) was then established which included both the Ministry of Works and Development and regional sites (240 sites in total). By the end of the 1980s, there were 15 hydrology field teams operating as the Water Resources Survey, a sub-division of the Department of Scientific and Industrial Research (DSIR).

In the mid-1980s, political emphasis on market forces and deregulation of the economy saw the introduction of "user pays" philosophies to water resource monitoring and the supply of data to users (see e.g. Mosley, 1987, for a general view of hydrology and user pays). A related development for Ministry of Works and Development field and database operations was the implementation of a quality assurance programme for hydrometric data collection to ensure users were confident the data were fit for use

(Mosley and McKerchar, 1989). By 1990 more than 500 water-level recorders were operating, either as part of the DSIR national network (290 stations for scientific and commercial purposes) or as part of local networks run by regional councils (for purposes such as water-resource allocation or flood warning).

Over this century, water levels have been recorded at over 1200 sites (open and closed) throughout New Zealand. Many of the data are stored on the central Water Resources Archive (national water quantity and quality databases) and on regional databases.

In July 1992 the National Institute of Water and Atmospheric Research Ltd (NIWA) was established, one of ten Crown Research Institutes. Surface-water hydrological field and scientific capabilities were transferred to NIWA. At that stage, a Government research programme provided most of the funding for the hydrometric sites; the rest were funded by other sources, principally the Electricity Corporation of New Zealand. Government science strategies indicated that research funding for hydrometric monitoring would be reduced from 1994 onwards, and that with the establishment of the Resource Management Act in 1991, water resource monitoring for non-scientific purposes would increasingly become the responsibility of regional councils. The NIWA network became known as the National Hydrometric Network. The National Hydrometric Reference Network lapsed at this stage: re-integrating regional council and National Hydrometric Network sites is discussed later.

Network reduction (1993/94)

In 1993, research was carried out to determine the best methods for reducing the National Hydrometric Network, for implementation in 1994. To objectively evaluate the merits of each of the stations operating within the network in 1993, Pearson (1993a, b, 1994) conducted a study using "Network Analysis Using Generalised Least Squares" (NAUGLS, see e.g. Tasker, 1986; Moss and Tasker, 1991; Pearson, 1991). NAUGLS ranks stations according to their potential to reduce the sampling uncertainty of a regional prediction equation over a specified future period. The generalised least squares algorithm can take into account the spatial correlation between flows from nearby river stations and the differing lengths of record for each station.

To apply NAUGLS, each NIWA-field-team region was treated as a homogeneous region. A logarithmic multiple regression, based on the model $Q = a A^{\beta} P^{\delta}$ (where Q is a flow variable of interest, A is catchment area, and P is catchment annual rainfall), was applied to each region; using the flow variables (Q) mean flow, mean annual minimum 7-day flow, and mean annual flood peak. NIWA stations already closed were used in the analysis, but stations operated by other agencies were not considered. Analysis was based on a planning period of 20 years.

For each region, stations were ranked using NAUGLS (Pearson, 1993a). Station rankings were similar for each of the three streamflow variables examined. Stations which were different to others in their region (in terms of either their explanatory variables (catchment area and precipitation or geographical location), and which had short records, were ranked highly for continued operation. For all 15 "regions", the reduction in sampling uncertainty decreased once ten or more stations were assumed to be operating in each region. Hence the top ten stations for each region contributed the most in terms of reducing regional uncertainties. To reduce the National Hydrometric Network to only 150 of the existing 290 stations, however, was not an option. Many assumptions and arbitrary choices were made for the NAUGLS study; some stations needed to remain open even though not selected by NAUGLS. Almost half of the 150 top-ranked stations were stations already closed; cutting the National Hydrometric Network in half would have been unpalatable to a wide range of groups with vested interests in the network.

A more pragmatic approach was taken, involving the establishment of a classification of stations for the National Hydrometric Network and the NAUGLS results.

I. Long-Term Stations: over 40 long-term, good quality stations were selected as Class I stations to be retained indefinitely for such purposes as monitoring long-term trends.

II. Science Stations: more than 150 stations were selected for specific scientific objectives such as monitoring river suspended sediment and water quality (Smith and McBride, 1990) and for ecological studies (Class II).

III. Commercial Stations: almost 100 stations were required for commercial purposes, mainly hydro-electric power generation (Class III).

IV. Nationwide-Coverage Stations: To ensure the revised National Hydrometric Network did in fact provide nationwide coverage, nearly 80 of the top 150 stations from the NAUGLS analysis were selected as Class IV stations (the open stations).

There was considerable overlap, as many of the stations were selected for more than one class, so that the total was 230 stations to operate from

1994 onwards, representing a 20% reduction in station numbers, and an approximately 20% reduction in cost, as required. Stations belonging to more than one class were funded on a pro-rata basis, so that purpose of use was connected to source of funding. The 60 stations that were closed were those not selected in Classes I-III and not appearing in the NAUGLS top ten for their region. This re-design of the National Hydrometric Network was presented at the November 1993 Hydrological Society's Annual Symposium (Pearson, 1993b) and implemented by NIWA on 1 July 1994.

Further re-design (1996)

In the two years following the 1994 reduction of the National Hydrometric Network, a number of problems and issues arose. Hydrologists and freshwater scientists in general (e.g. stream ecologists), and many other users of the data (including the Ministry of Research, Science and Technology), felt that the 20% cut in numbers of stations was too severe. Many were unhappy that NAUGLS was used, even if only to fill spatial gaps left by Classes I-III. It was thought that NAUGLS involved too many assumptions and arbitrary choices.

Another major problem was that some of the scientific studies for which the Class II stations were required had reached or neared completion. For example, one major scientific project was a study of suspended sediment loads in New Zealand rivers (Hicks *et al.*, 1996). Sediment gaugings were made at 80 streamflow recording sites (1992-97). Using these data, together with data already available in the Water Resources Archive and regional council databases, this study analysed sediment and streamflow relationships for 240 sites (1995-97). Data analysis, including developing regression equations for prediction of sediment yields (1996/97) and relationships between sediment particle size and catchment geology (1997/98) continues, however, data collection has ended. Many of the 80 hydrometric sites used in that study are kept operating for other concurrent and future studies (e.g. trend analysis).

Class III station membership can fluctuate annually according to the requirements of funders. In October 1996, New Zealand's electricity market was deregulated, so there are now a range of hydro-electricity providers, with fluctuating demands for hydrometric data (largely real-time).

The overall structure (Classes I-IV above) was changed on 1 July 1996. Most "science" sites (Class II) were being used for more than one specific scientific project; these were merged with the nationwide-coverage sites (Class IV). Overall, the same stations continue to operate (230 in total), and will continue to do so until the current research contract expires at 1 July 1998, when a new contract will begin. Over this two year period, the National Hydrometric Network structure has become:

I. Long-Term Stations: the same long-term, good quality stations as before (40+);
II. Nationwide-Coverage Stations: Old Class II and IV stations (over 180 stations);
III. Commercial Stations: as before, approximately 100 stations.

Figure 1 shows the location of the recorders and the upstream contributing catchments for the network. Single-purpose science sites are shown as short-term sites. Spatial gaps, such as in the Northland, Auckland, Manawatu, Canterbury and Southland regions, are covered by regional council networks (as are most other regions which do not appear as spatial gaps on Figure 1).

Future network and database structure

The objective since 1 July 1996 has been to continue operation of the network at the same level, ensuring that data collection and database practices maintain their quality-assured status (ISO 9002). More emphasis is being placed upon communication with the users of national hydrometric data, including the managers of the regional council networks. An electronic-mail group was established in March 1997 for this purpose. A particular goal is to re-establish the National Hydrometric Reference Network, incorporating NIWA's National Hydrometric Network and regional and district council networks. For the Water Resources Archive, internet linkages amongst databases of other hydrometric networks and different network types are planned, so that water resource and environment scientists, including hydrologists, can gain easier access to New Zealand environmental data.

Water Resources Archive data are used by more than 25 other research programmes, and results are reported in over 30 papers per year. In this, and many other ways, the data collected by the National Hydrometric Network and regional councils are used to provide information on national and regional trends and distribution of New Zealand's freshwaters (e.g. for flood hazards: McKerchar and Pearson, 1989; and more recently, Madsen *et al.*, 1997; for low flows: Pearson, 1995; for river water quality: Smith *et al.*, 1996).

Another ranking of National Hydrometric Network stations, particularly

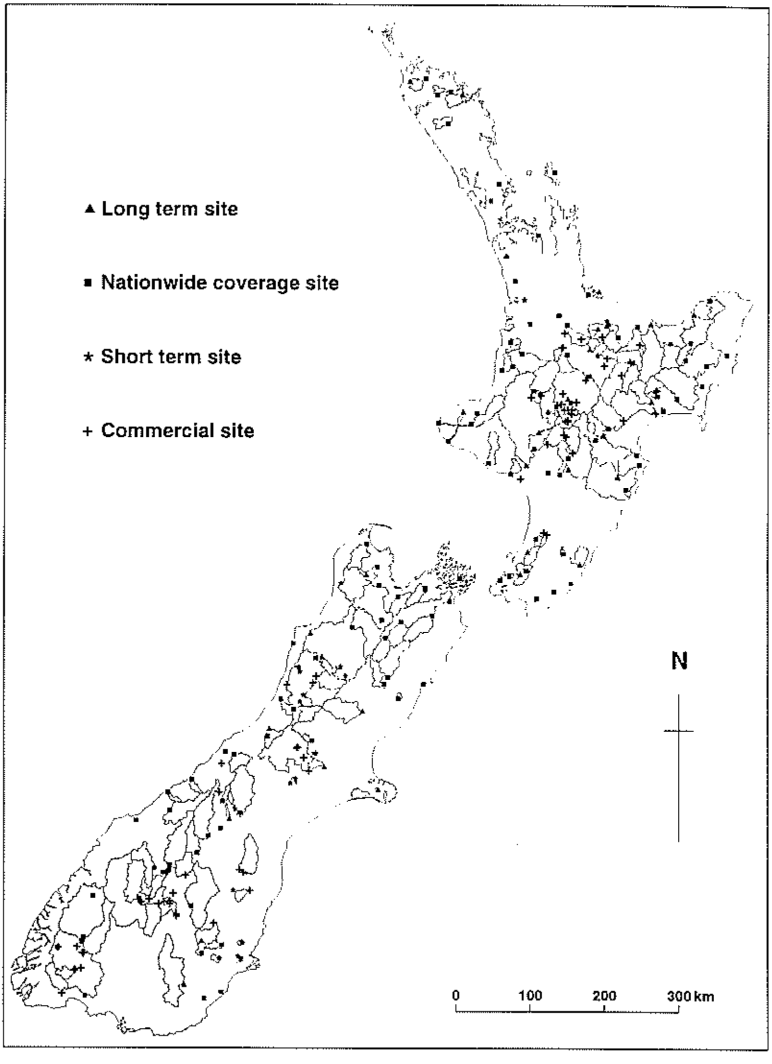


Figure 1 – Location and upstream catchment areas of water-level recording sites of the National Hydrometric Network (as at 30 June 1997). Short-term sites are those which are operated by other science programmes for a single scientific purpose.

for those belonging only to the new Class II above, is required before 1 July 1998, so that any changes in funding at that stage can be acted upon (no reduction in research funding is anticipated). For this new ranking, network design methods are being reviewed and developed. Input from data users on the structure of the National Hydrometric Network, and its integration with regional council networks, is sought, and may be incorporated into the network design.

Network-design research and flow-variability information

Theory

To maximise the information collected within a given budget, it is necessary to design and manage a network in some optimal fashion, and to review it on a regular basis. Two objective methods for river flow networks were compared by Moss and Tasker (1991) as part of a World Meteorological Organisation project (HYNET): Network Analysis for Regional Information (NARI) and Network Analysis Using Generalised Least Squares (NAUGLS). Both methods (Pearson, 1991) were based on regression equations for river flow, using explanatory variables such as catchment area and precipitation. Prediction of how the standard error of the regression varied according to different network configurations was the basis of each network design method.

NAUGLS has been shown to be superior to NARI (Stewart *et al.*, 1996), and at this stage is regarded as the best available framework for network design.

Other approaches based on concepts of entropy (e.g. Caselton *et al.*, 1992; Yang and Burn, 1994) and information (e.g. Moss, 1986) have been proposed, and considered for use for the National Hydrometric Network. Network designs that address user's preferences and purposes, such as making decisions on sustainable management of water resources, could also be developed (e.g. Bender and Simonovic, 1997). Knowledge and needs of the wider community could be blended into a consensus view on priorities for hydrological monitoring.

Moss (1986) defined flow information functions on a river catchment by summarising water-quantity information available over time (to date) and space within a catchment. Moss proposed using information derived from models of the underlying physical processes (e.g., by applying established hydrological "laws" (Dooge, 1986) such as rainfall runoff models and hydraulic channel routing models, to available flow, and other data). Flow information all along a catchment's river channel network can be estimated. For network design, this definition of catchment information is incorporated into an optimal decision model (e.g. NAUGLS). Generally, a decision action space mathematical framework would be used to assess risks of certain decisions, and identify optimal decisions (i.e., those concerning the future configuration of the network) based on minimising these risks (DeGroot, 1970). The action space for decisions is how many, and which, recording stations should continue to operate over the next planning period. Zellner (1988) gives some useful theory on using information functions in Bayesian decision situations.

Application to the National Hydrometric Network

The 1993/94 NAUGLS network design of the National Hydrometric Network was based on variables primarily of interest to hydrologists (mean flow, mean annual minimum 7-day duration flow, mean annual flood peak). These statistics from the low, middle and high parts of the flow regime provide indirect information on the variability of the flow at a site. Flow variability is a good surrogate for the amount of information provided by the hydrograph signal – information content is of primary interest to all users of hydrological data for decision making. Confidence in decisions is related to the confidence (and the amount of information) in the data. Hence by using flow variability for network design there is a more direct link between data collection and data users, and resource decision-makers, such as all water-related scientists (including hydrologists, water quality scientists, stream ecologists) and managers (hydropower operations, water resources).

Flow variability in New Zealand rivers has been studied by a number of investigators. Jowett and Duncan (1990), for the "100 Rivers" project, found that the coefficient of variation of flow was a good measure of flow variability. In this study, the standard deviation of annual mean flow was analysed for 76 North Island catchments. These catchments, all of which have 20 or more years of concurrent water-level and river-flow records (1971-90), were used for the World Meteorological Organisation HYNET study (Pearson, 1991; World Meteorological Organisation, 1992; Stewart *et al.*, 1996). Analysis of standard deviations was the second phase of the HYNET study.

The multiplicative regression model for standard deviation of annual mean flow (σ_{AMF}) for sites of the HYNET data set is (Pearson, 1991):

$$\sigma_{AMF} = \alpha A^{\beta} P^{\delta}$$

where σ_{AMF} is in m^3/s, A is catchment area (km^2), and P is catchment mean annual rainfall (mm). Taking logarithms (base 10) of this equation gives a linear regression equation:

$$\log(\sigma_{AMF}) = \log(\alpha) + \beta \log(A) + \delta \log(P)$$

which is the linear model used in the following regressions, and was also used for mean flow (μ_{AMF}; results presented in Pearson, 1991). Appendix 1 lists the HYNET sites and their corresponding estimates of μ_{AMF}, σ_{AMF}, A (from Walter, 1994), and P (from New Zealand Meteorological Service, 1985). The regression results for σ_{AMF} are presented in Table 1 and Figure 2, and compared with the results for μ_{AMF}. Although the regression for σ_{AMF} is not as good as that for μ_{AMF}, it is still useful for prediction of σ_{AMF} at ungauged North Island river locations. Regression standard errors of estimates for σ_{AMF} are (-32%, +47%), whereas those for μ_{AMF} are more precise (-23%, +29%) (Table 1). The use of the σ_{AMF} regression model for the second phase of HYNET confirmed the result from the first phase (using μ_{AMF}) that NAUGLS is a better network design framework than NARI, based on data from Australia, Germany, Malaysia, Morocco, New Zealand and the United States of America (Stewart *et al.*, 1996).

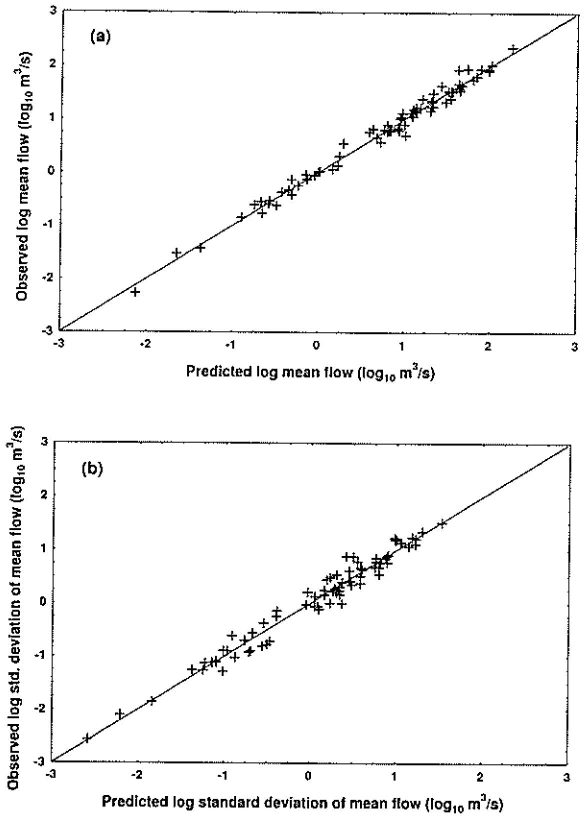
Table 1 – Regression results for mean (μ_{AMF}) and standard deviation (σ_{AMF}) of annual mean flows for the 76 North Island streamflow recording sites used for HYNET (sites and data listed in Appendix 1).

Flow Variable	$\log(\alpha)$	β	δ	r^2 (%)	Standard Error (%)
σ_{AMF}	-5.641	0.973	1.087	96.4	(-32, +47)
μ_{AMF}	-6.678	1.040	1.559	98.6	(-23, +29)

Future developments

Use of other measures of streamflow variability (other than σ_{AMF}) as the focus of network design using the NAUGLS framework, with more physically meaningful independent variables than the broad, empirical A and P variables, is being considered for the National Hydrometric Network.

Figure 2 – Observed versus predicted (a) mean and (b) standard deviation of annual mean flows from the 76 North Island streamflow recording sites used for HYNET (sites and data listed in Appendix 1). A map of these catchments is presented in Pearson (1991).



Kovacs (1986) postulated that streamflow variability was dependent upon three catchment hydrological processes at different spatial and temporal scales. This is summarised in the following regression model which can be used in the NAUGLS framework. A model for variance of streamflow (σ^2, standardised by the square of mean flow μ^2) is:

$$(\sigma/\mu)^2 = \alpha\,\sigma_{SS}^{\;2} + \beta\,\sigma_{IS}^{\;2} + \delta\,\sigma_{CN}^{\;2}$$

where σ/μ is the coefficient of variation of flow (see Appendix 1 for σ/μ

of annual mean flow), $\sigma_{SS}{}^2$ is a measure of the variance of smooth spatial catchment properties (e.g. variance of catchment rainfall), $\sigma_{IS}{}^2$ is a measure of the variance of irregular spatial catchment properties (e.g. heterogeneity of catchment geology and soils), $\sigma_{CN}{}^2$ is a measure of the variance of the catchment channel network drainage pattern, and α, β and δ are coefficients to be estimated by regression. This equation neglects possible non-zero covariances amongst the catchment variances, which will have to be considered. However, for different catchment sizes, only one or two of the catchment variances may be required to satisfactorily explain streamflow variance.

For $\sigma_{SS}{}^2$, a measure of rainfall spatial variability over a catchment will be investigated, possibly annual rainfall isohyets (New Zealand Meteorological Service, 1985). For $\sigma_{IS}{}^2$, a measure of the landform heterogeneity will be used, using spatial data of the Land Resource Inventory (Newsome, 1992). For $\sigma_{CN}{}^2$, a measure of channel network variability will be used that is based on recent research results (see e.g. Nikora *et al.*, 1996). Topographic variability measures representing the variability of hillslope fluxes (Woods and Rowe, 1996) and channel networks will also be considered for $\sigma_{IS}{}^2$ and $\sigma_{CN}{}^2$. There is potential to use remotely sensed data to estimate these three variances (Engman 1996). If it can be shown that streamflow variability (i.e. $(\sigma/\mu)^2$) can be predicted using these variances, combined with remotely sensed data and the NAUGLS framework, this will be a useful advance for network design in New Zealand and remote regions of the world.

Final remarks

Government adoption of "market forces" and "user-pays" philosophies in the late 1980s led to a reduction in the number of stations forming New Zealand's National Hydrometric Network. The subsequent reaction from major users of this network, including hydrologists and freshwater scientists, indicates that station numbers should not be reduced below present levels. The network-design methodology NAUGLS was useful in identifying stations which contributed the least to reducing sampling uncertainty of regional regressions for low, mean and flood flows. Better ways in which to use NAUGLS are being developed.

There is a continued need for hydrometric data collection for resource management, and for current and future scientific and environmental studies. Continuity of streamflow time series is essential for assessing the effects of climate change and changes in catchment land use. Hydrological time series are short compared with many meteorological time series.

Alarmingly, the numbers of hydrometric sites, which reached a peak during the International Hydrological Decade, 1965-74, are decreasing worldwide. Recorded flow at a river location is an integration of all catchment processes upstream of that point, but the information provided by that recorder diminishes rapidly as we move up or downstream. Despite the extensive networks operating within New Zealand, there is still a paucity of spatial information. To fill these information gaps requires ongoing hydrological research.

Acknowledgments

This work was funded by the Foundation for Research Science and Technology (FRST, contract CO1417, "Information on New Zealand's Freshwaters" – a FRST "nationally important" research programme funding much of the National Hydrometric Network (class I and II sites and network design research), the National River Water Quality Network and the Water Resources Archive – national water quantity and quality databases). Alistair McKerchar and Mauri McSaveney are thanked for constructive review comments, and Kathy Walter is thanked for producing Figure 1. Eileen McSaveney is thanked for editorial suggestions.

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Manuscript received: 1 July 1997; accepted for publication: 22 December 1997.

Appendix 1

North Island streamflow recording sites used for HYNET (Pearson 1991) – 76 sites with complete records for the period 1971-1990, mean (μ_{AMF}) and standard deviation (σ_{AMF}) of annual mean flows, and coefficient of variation (σ/μ). A map of these catchments is presented in Pearson (1991).

Site Number (Walter 1994)	River	Area (A, km^2)	Annual Rain (P, mm)	Mean (μ_{AMF}, m^3/s)	Standard Deviation (σ_{AMF}, m^3/s)	Coefficient of Variation (σ/μ)
1316	Awanui at School Cut	220	1770	6.10	1.41	0.23
3506	Maungaparerua at Tyrees Ford	11.1	2320	0.463	0.123	0.27
4901	Ngunguru at Dugmores Rock	12.5	1900	0.419	0.125	0.30
7604	Wairau at Motorway	11.1	1290	0.243	0.0539	0.22
9140	Piako at Paeroa Tahuna Rd Br	534	1150	6.75	1.71	0.25
9205	Waihou at Te Aroha Br	1130	1460	41.9	5.97	0.14
9213	Ohinemuri at Karangahake	305	1790	12.9	3.37	0.26
9301	Kauaeranga at Smiths	121	2000	6.55	1.58	0.24
14628	Mangorewa at Saunders Farm	185	2370	6.17	0.995	0.16
15408	Rangitaiki at Murupara	1140	1560	21.0	3.47	0.17
15410	Whirinaki at Galatea	509	1590	14.3	2.54	0.18
15511	Waimana at Waimana Gorge	467	2240	17.0	4.45	0.26
15514	Whakatane at Whakatane	1560	2020	54.4	13.7	0.25
15534	Wairere at Wainui Rd	2.67	1320	0.0371	0.0139	0.37
15536	Waimana at Ogilvies Br	206	2420	7.88	1.83	0.23
15901	Waioeka at Gorge Cable	662	2370	32.3	7.12	0.22
16501	Motu at Houpoto	1380	2000	88.0	15.6	0.18
16502	Motu at Waitangirua	293	2120	13.0	2.48	0.19
19716	Waipaoa at Kanakanaia C/W	1570	1420	32.4	7.57	0.23
21409	Waiau at Otoi	534	2030	21.2	4.23	0.20
21410	Waihi at Waihi	50.2	2020	2.00	0.559	0.28
21801	Mohaka at Raupunga	2370	2000	79.7	16.1	0.20
21803	Mohaka at Glenfalls	1040	2110	38.0	7.97	0.21
22802	Esk at Waipunga Br	253	1570	5.83	1.72	0.30
23005	Ngahere at Ngahere Wei	0.521	2600	0.0292	0.00788	0.27
23104	Ngaruroro at Kuripapango	385	2600	17.0	3.20	0.19
23201	Tukituki at Red Br	2380	1200	45.4	15.3	0.34
23209	Otane at Glendon	23.3	900	0.168	0.0805	0.48
23210	Omakere at Fordale	53.7	1390	1.04	0.413	0.40
25902	Whareama at Waiteko	400	1200	6.46	3.01	0.47
29201	Ruamahanga at Wardells	640	1540	24.1	6.02	0.25
29202	Ruamahanga at Waihenga	2340	1200	84.5	16.8	0.20
29224	Waiohine at Gorge	184	4250	30.4	7.44	0.24
29231	Taueru at Te Weraiti	398	1100	6.34	2.76	0.44
29242	Atiwhakatu at Mt Holdsworth	40.2	2520	3.52	0.705	0.20
29244	Whangaehu at Waihi	36.3	1240	0.559	0.198	0.35
29250	Ruakokopatuna at Iraia	15.5	1950	0.711	0.239	0.34

Site Number (Walter 1994)	River	Area (A, km²)	Annual Rain (P, mm)	Mean (μ_{AMF}) m³/s)	Standard Deviation (σ_{AMF}, m³/s)	Coefficient of Variation (σ/μ)
29808	Hutt at Kaitoke	87.2	3210	7.75	1.32	0.17
29818	Hutt at Birchville	426	2390	22.1	4.64	0.21
30516	Mill Ck at Papanui	9.10	1180	0.140	0.0557	0.40
30701	Porirua at Town Centre	44.6	1260	0.733	0.269	0.37
32531	Mangatainoka at Suspension	406	1880	16.3	3.97	0.24
32563	Oroua at Kawa Wool	575	1380	11.1	2.59	0.23
1032560	Manawatu at Teachers College	3910	1500	105	22.0	0.21
32702	Rangitikei at Mangaweka	2690	1500	62.9	11.5	0.18
33107	Whangaehu at Karioi	471	2170	14.2	2.33	0.16
33111	Mangawhero at Ore Ore	511	1620	13.4	2.20	0.16
33114	Waitangi at Tangiwai	53.1	1360	1.01	0.154	0.15
33115	Mangaetoroa at School	32.7	1520	0.888	0.117	0.13
33117	Makotuku at SH49A Br	20.6	2390	0.870	0.126	0.14
33301	Wanganui at Paetawa	6640	1500	221	32.5	0.15
33302	Wanganui at Te Maire	2210	2100	85.9	12.8	0.15
33316	Ongarue at Taringamutu	1080	1700	33.3	5.88	0.18
33320	Whakapapa at Footbridge	173	3170	15.2	1.980.	13
33347	Wanganui at Te Porere	27.1	2990	1.33	0.1900.	14
33356	Wanganui at Piriaka	841	2510	42.8	5.73	0.13
36001	Punehu at Pihama	30.9	2490	1.15	0.166	0.14
39501	Waitara at Tarata	705	2370	33.2	4.62	0.14
43433	Waipa at Whatawhata	2820	1560	87.3	17.2	0.20
43435	Waipapa at Ngaroma Rd	134	1760	5.66	0.934	0.17
43472	Waiotapu at Reporoa	232	1480	3.71	0.756	0.20
1043419	Pokaiwhenua at Puketurua	430	1500	4.99	0.967	0.19
1043427	Mangakino at Dillon Rd	342	1610	10.8	1.55	0.14
1043428	Tahunaatara at Ohakuri Rd	195	1550	4.50	0.852	0.19
1043434	Mangakara at Hirsts	21.5	1570	0.376	0.0942	0.25
1043459	Tongariro at Turangi	772	2600	34.4	6.89	0.20
1043460	Tongariro at Puketara	503	2930	24.1	4.68	0.19
1043461	Tongariro at Upper Dam	182	3030	11.3	1.42	0.13
1043466	Waihohonu at Desert Rd	95.8	3170	5.97	0.865	0.15
1143409	Purukohukohu at Puruki	0.344	1700	0.00536	0.00273	0.51
1143428	Ohote at Rotokauri	14.6	1390	0.290	0.0766	0.26
1443495	Tongariro at Rangipo Barrage	216	3080	16.2	7.56	0.47
43602	Waitangi at SHBr	17.8	1380	0.236	0.0523	0.22
45702	Waiwhiu at Dome Shadow	8.20	1770	0.279	0.0747	0.27
46618	Mangakahia at Gorge	244	2000	10.1	1.68	0.17
47527	Opahi at Pond	10.0	1760	0.253	0.0758	0.30