workingpaper

Evaluating the Water Resource Dataset

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About the Resource Project Team

The Resource Project Team comprises of Jessica Prendergast, Nicola Bradshaw, Chris Aitken, Lisa Bazalo, Jean-Charles Perquin, and Steph Versteeg. Each team member has placed a significant amount of time and effort into each Working Paper and the corresponding datasets.

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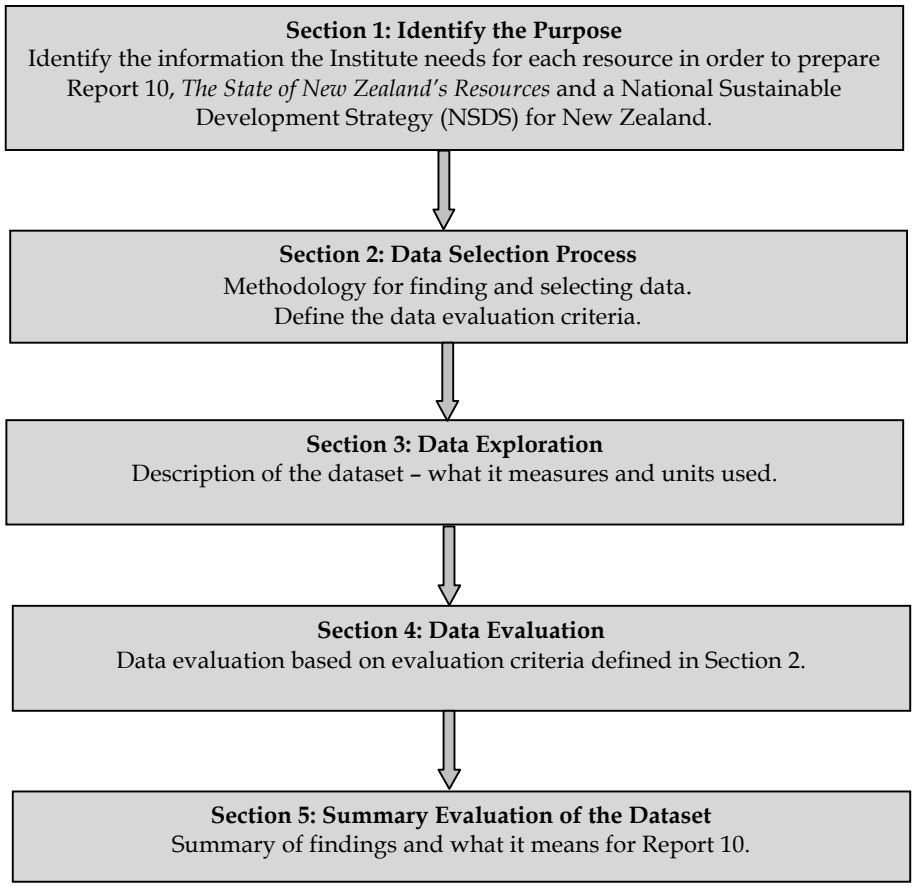
1. Purpose

This Working Paper is one of a series of 11 papers prepared as background to the Sustainable Future Institute's Report 10, *The State of New Zealand's Resources* (SFI, in press). Report 10 aims to provide an overview of available data and information covering a range of resources, and to discuss the use, availability and appropriateness of the data in the preparation of a National Sustainable Development Strategy (NSDS).

The purpose of this Working Paper is to describe the process by which the Institute collected, collated and presented a selection of New Zealand water resource data. The datasets are summarised and evaluated for completeness, accuracy, relevance, appropriateness of sources and public availability. This paper also discusses the purpose for which the data was collected by its custodians, and why the Institute has selected this data for it's reporting. The context of the dataset is not interpreted or analysed; rather, our purpose is to evaluate the usefulness of the dataset for the purposes of Report 10.

Following this evaluation any gaps and resulting limitations in using the selected data are assessed, as well as the data's relevance and reliability in relation to the Institute's purpose of using the comprehensive series of datasets to inform the development of an NSDS for New Zealand. A short glossary is included at the end of the Working Paper.

Figure 1 The Five-step Process for Evaluating the Institute's Datasets



1.1 The Sustainable Future Institute

The Institute is an independently funded think tank based in Wellington, New Zealand. Earlier work by the Institute has indicated that New Zealand is well behind other developed countries on its international obligations to develop and implement a National Sustainable Development Strategy (NSDS) (SFI, 2007). It is hoped that *Project 2058* will help inform ministers, policy analysts and members of the public about key events and trends in New Zealand's past, and alternative strategies for the future. With this in mind, this Working Paper is a step towards the Sustainable Future Institute's goal of preparing an NSDS for New Zealand in 2011.

1.2 Project 2058

The strategic aim of *Project 2058* is to promote integrated long-term thinking, leadership and capacity building so that Aotearoa/New Zealand can effectively seek and create opportunities, and explore and manage risks, over the next 50 years. In order to achieve this aim, the *Project 2058* team is working to:

1. Develop a detailed understanding of the current national planning landscape, and in particular the government's ability to deliver long-term strategic sustainability thinking;
2. Develop a good working relationship with all parties that are working for and thinking about the 'long-term view';
3. Recognise the goals of iwi and hapū, and acknowledge te Tiriti o Waitangi;
4. Assess key aspects of New Zealand's society, asset base and economy in order to understand how they may shape the country's long-term future, such as government-funded science, natural and human-generated resources, the state sector and infrastructure;
5. Develop a set of four scenarios to explore and map possible futures for New Zealand;
6. Identify and analyse both New Zealand's future strengths and weaknesses, and potential international opportunities and threats;
7. Develop and describe a desirable sustainable future in detail, and
8. Prepare a *Project 2058* National Sustainable Development Strategy. (SFI, 2009: 3)

The culmination of *Project 2058*, the creation of a National Sustainable Development Strategy, depends on having an accurate assessment of key aspects of New Zealand society. Earlier reports have dealt in particular with points 1, 3, 5 and 6 above,[1] and this Working Paper is designed to help progress the fourth point: 'Assess key aspects of New Zealand's society, asset base and economy in order to understand how they may shape the country's long-term future …'

1.3 Water Resources within an NSDS

Below we ask six strategic questions that drive this research. These are then expanded upon to discuss the use, availability and appropriateness of the data in the preparation of an NSDS.

[1] For a detailed list of published and upcoming reports, see *Project 2058 Methodology: Version 3* (SFI, 2009: 7).

Without accurate, comprehensive, relevant and accessible data to answer the following questions, it will be difficult to develop and execute an informed NSDS for New Zealand.

- **What** are the issues facing water resources and water use in New Zealand? Are New Zealanders clear on exactly what these issues are? Does New Zealand have quality data and information to enable us to understand these issues as fully as possible? Are New Zealanders able to establish an informed understanding of the priorities?

- **Why** does New Zealand need to confront issues affecting water resources? Are there improvements that can be achieved; or practices that need to change? Are current indicators relevant and meaningful to benchmark changes over-time? What is the purpose and the benefit in taking action?

- **When** should New Zealand start to address issues which impact on New Zealand's water resources? Is now the right time? Are current economic, social and environmental conditions conducive? Would it be beneficial to wait and monitor events as they evolve? Are current measures and indicators appropriate to monitor developments? Is there a risk of rushing into short-term action when a long-term approach is needed?

- **Where** do New Zealanders most need to concentrate their efforts to address New Zealand's water resource issues? Which aspects of the issue should be focused on first? Where should New Zealanders begin to ensure the most beneficial and sustainable outcome? Does New Zealand have sufficient knowledge, based on accurate and appropriate data, to assess outcomes?

- **Who** must be engaged to effectively address issues facing water resources in New Zealand? Who needs to be involved if New Zealand is going to successfully tackle these issues? Is data on water resources in New Zealand accessible and transparent to allow those interested to be accurately informed? Are data ownership issues affecting public involvement?

- **How** should New Zealand ensure we have effective water resource management? What is the best approach? What skills or techniques are needed? Does New Zealand have comprehensive and accurate information to enable effective management? How can New Zealand learn from international experience to assist in maximising effective and sustainable water resources?

This working paper does not attempt to answer the above overarching questions. These overarching questions do however inform our purpose for Report 10 and in progressing an NSDS. Data collected for inclusion within this dataset has enabled us to understand the level of accuracy, relevance, comprehensiveness and issues of ownership that exist surrounding publicly available data in New Zealand. The above questions function as a bridge between the dataset, this Working Paper and Report 10; specific questions pertaining to how the selected Institute's dataset will inform the development of an NSDS are outlined in Table 1.

2. Data Selection Process

2.1 Methodology

Report 10a, *Designing a Framework to Monitor New Zealand's Resources* (SFI, 2010a) outlined the process though which the Institute developed the framework for connecting and presenting the data. With this framework in place, the steps towards the completion of Report 10 are: (i) building the datasets for the 11 resource types studied; (ii) evaluating the selected datasets, and (iii) reporting on the findings in relation to the Institute's aim of defining an NSDS for New Zealand. The datasets developed in step (i) are available on our website.[2] This Working Paper is one of 11 that form step (ii), the data evaluation. Step (iii) will be published in Report 10.

The source data for the Institute's Water Resources Dataset was selected from a variety of static tables, extracted from the Statistics New Zealand website. The tables used are listed on the Institute's website under Project 2058 Publications and State of New Zealand's Resources. The Institute has taken the original data and reformatted it in an Excel spreadsheet to facilitate use and analysis. The original data values have been preserved.

2.2 Sources of Data

The Institute supports the free availability of data relating to environmental statistics. With this in mind, we deliberately used only openly accessible data so that we were able to report on its availability and identify potential gaps. This enables us to report on the implications of using only freely available data, and to evaluate the information that can be extracted from these data sources.

We acknowledge that many sources of information exist on New Zealand's water resources that may or may not be publicly available or easily discoverable. Crown Research Institutes (CRIs), universities, national and local government, and other private and public organisations also collect and hold data on water resources.

For various reasons including privacy, commercial sensitivity, cost of dissemination or commercial sale price of the data, there are many datasets on New Zealand's resources that are inaccessible to the public. Without extensive research, funding or expertise to assist in the interpretation of the data, many others remain unavailable. The Institute has focused on open data and therefore no efforts have been made to retrieve the other datasets. This is a limitation of this project as gaps identified by the Institute could potentially be filled by these other data sources.

For example, NIWA's National Centre for Water Resources (NCWR) provides public information on river, lake, and groundwater conditions across New Zealand including water quantity and quality. It also acts as a distribution point for new technology and management tools for water-related issues. Examples include the development of linked databases containing a wide variety of aquatic information. Scientists at the Centre are active in

[2] www.sustainablefuture.info

monitoring and researching New Zealand's freshwater systems, particularly the influences of changes in land-use and climate variability on both the physical and biological aspects of rivers, lakes, wetland and aquifers (NIWA, 2010).

Regional councils also have important responsibilities for environmental, water quality and water quantity management under the Resource Management Act (RMA) 1991 (RMA, 1991). There is therefore a wealth of very relevant information that NIWA and regional councils could provide, which would make the Institute's Water Resources Dataset more comprehensive. Some of this data has been included and presented as part of the Statistics New Zealand data, the primary source of this report.

Statistics New Zealand notes that from 1983 through to 1988, the Ministry of Agriculture and Fisheries summarised much of the existing information on New Zealand's freshwater on a region-by-region basis. This was one of the few attempts to provide a systematic overview of the state of our waters at the national level, and no repetition of these baseline surveys has been undertaken (Statistics New Zealand, 2004a: 15). However, P. Prendergast, (former Principal Public Health Engineer at the Ministry of Health) observed that such information was normally collected by the Water and Soil Directorate of the Ministry of Works and Development (MWD) who administered the Water and Soil Conservation Act 1967 – the forerunner of the Resource Management Act (RMA). MWD was abolished in 1988 and all functions assigned to Regional Water Boards (now Regional Councils) and hence the collection of information nationally ceased until the Ministry for the Environment started collecting this data again for its 1997 *The State of New Zealand's Environment* report (P. Prendergast, personal communication).

In 1997, MfE prepared the report *The State of New Zealand's Environment*, which included a general overview of the state of and pressures on our water resources, this was followed up with the *Environment New Zealand 2007* report which provided further information on the state New Zealand's water resources. Many regional councils have also published 'state of the environment' reports containing data on water resources (Statistics New Zealand, 2004a: 14). Another potential source of information on water resources is Water Information New Zealand (WINZ), a drinking water quality database owned by the Ministry of Health and managed by Environmental Science and Research (ESR), another Crown Research Institute (CRI). This database holds water quality information on all registered water supplies in New Zealand including on the quality/testing carried out on their source waters.

The Institute searched for and compiled its dataset in 2009. What we have selected for inclusion in this dataset and for discussion within this Working Paper reflects data which fits our purpose and was available within the environmental data landscape at the time of research.

As data availability increases rapidly on an ongoing basis, it would not be practical to include within this Working Paper here all datasets relevant to water resources in New Zealand. Report 10 investigates the past, present and future of the environmental data landscape in New Zealand. It also provides a list of alternative sources of information pertaining to New

Zealand resources. When appropriate, we have mentioned complimentary data sources in this Working Paper.

Data on New Zealand resources is often produced and targeted to industry experts. This makes a thorough analysis and evaluation of datasets a complex task for the uninitiated. We have referred to the original source documents to support our evaluation of the datasets.

2.3 Water Resources Dataset Evaluation Criteria

The Institute has developed a series of criteria to support the effective evaluation of the datasets and to consider the data in the context of our wider work programme. Each criterion is supplemented with questions to direct attention to relevant areas for consideration. The aim is to structure the analysis of each dataset in a way that is consistent and replicable across the 11 datasets. In this Working Paper, these criteria are applied to the Water Resources Dataset as a whole, and to the different indicators and sources that comprise the dataset.

The criteria and guiding questions are outlined in Table 1.

Table 1 Criteria for Evaluating Institutes Datasets

Criteria for evaluation	**Guiding questions**
Comprehensive time series	For how long has the data been collected? Are there gaps in the records? Are data/indicators consistent and comparable over time?
Quality data	What is the scope and range of indicators; are there any gaps? Is data comprehensive and detailed? How is data classified/categorised? Is the data local/regional/national? Is the data internationally comparable and valid? Is the data accurate – is there any sampling bias? Are error bars calculated? Is the data relevant and able to be interpreted with meaning?
Appropriate sources	How many sources are drawn on, and what are they? Who owns the data? Why, how and where is data collected/measured? Is it original data, self-reported/obtained by survey? Is the data collection and analysis informed by sound assumptions? Is data reliable, independent, verifiable and/or of international standard? Is the data subject to (external) review?
Publicly available	Is the data easy to access? Is the data located online, in publicly available reports or databases, or within institutions? Is the data freely available?

2.4 Selected Sources

In order to find possible sources of water resource data to establish a baseline portrait of water resources in New Zealand, the websites of agencies and organisations with relevant links to New Zealand's water resources were reviewed for all publications which provided information on water resources in New Zealand. Statistics New Zealand's physical stock account for water was selected as the primary source of data for the following reasons. Firstly, the freshwater stock account was the first dataset of its type to be developed for water in New Zealand (Statistics New Zealand, 2004a: 9, 14). Secondly, although water is strictly monitored by regional councils and a number of other agencies, available national data is somewhat limited. The Institute found the Statistics New Zealand's physical stock account to be the most comprehensive and consistent source of publicly available online data.

The Water Resources Dataset has been compiled from a physical stock account prepared by Statistics New Zealand. Physical stock accounts typically convey opening and closing stocks of water resources, and the flows that affect these stocks. However, because there is limited data on opening and closing stocks in New Zealand, the dataset has instead been presented in terms of inflows, outflows and changes in stock volumes (Statistics New Zealand, 2004a: 10). A substantial amount of information has been drawn from the *Water Physical Stock Account: 1995–2005* (Statistics New Zealand, 2007), which assesses the stock in great detail and therefore provides an excellent basis for the Institute's dataset.

Data for freshwater inflow and outflow volumes, change in storage volumes, abstraction volumes and discharge volumes was supplied to Statistics New Zealand by the Ministry for the Environment (MfE) and the National Institute of Water and Atmospheric Research (NIWA). Data for groundwater stock volumes was provided to Statistics New Zealand by the Institute of Geological and Nuclear Sciences (GNS Science).[3]

2.5 Purpose for which the Data was Initially Collected

Statistics New Zealand measures New Zealand's water resources in terms of 'stocks' and 'flows', other agencies use the term 'volumes' in lieu of 'stocks'. For reasons of consistency with this papers main source, Statistics New Zealand, we use the term 'stocks' throughout this working paper. Stocks are the volume of lakes, rivers and groundwater. Flow rates are the volume and rate of rainfall and include other rates, such as but not limited to, the run-off and evaporation rate.

> Knowing how much water is falling, flowing, and stored in New Zealand is important for agriculture, forestry, electricity generation, flood and erosion control, drought impact management, urban water supply, recreational use of rivers, and maintaining the habitat and biodiversity of fish and other stream and river life. (MfE, 1997: 7.10)

Physical stock account data was collected by MfE and NIWA and collated by Statistics New Zealand to fill a gap in the reporting of statistical measures regarding the natural environment, and the impact of economic and social activities on the environment (Statistics

[3] These databases are available on the Statistics New Zealand website at http://search.stats.govt.nz/search?w=water

New Zealand, 2004a: 9). The water accounts were developed as part of a set of natural resource accounts for New Zealand (Henderson et al., 2007: 1).

Statistics New Zealand suggests that the tables in the stock accounts can help in assessing:

- regional and national availability and scarcity of the resource;
- effects of El Niño/Southern Oscillation (ENSO) and Interdecadal Pacific Oscillation (IPO) cycles;
- regional and national water usage;
- interactions between the environment and the economy; and
- effects on the water resource of structural and policy change in other sectors.

(Statistics New Zealand, 2004a: 14)

3. Data Exploration

The same indicators and units were used for both surface water (data sourced from MfE) and groundwater (sourced from NIWA), and were both regrouped by Statistics New Zealand (Statistics New Zealand, 2007:11). The Institute's dataset is divided into six categories: (i) Freshwater inflow volumes; (ii) Freshwater outflow volumes; (iii) Change in storage volumes; (iv) Abstraction volumes; (v) Discharge volumes, and (vi) Groundwater stock volumes.

Table 2 Water Resources Dataset Summary Table

Dataset Category	Data Presented	Dates	Measures	Data Reporting Frequency
Freshwater inflow volumes	Precipitation	1995–2005	Mm^3 (million cubic metres)	Annual
Freshwater outflow volumes	Evapotranspiration	1995–2005	Mm^3 (million cubic metres)	Annual
	Outflows to sea and net abstraction			
Change in storage volumes	Soil moisture	1995–2005	Mm^3 (million cubic metres)	Annual
	Lakes and reservoirs			
	Groundwater			
	Snow			
	Ice			
Abstraction volumes	For irrigation	1995–2005	Mm^3 (million cubic metres)	Annual
	For hydroelectricity generation			
	For municipal supply and domestic use			
	For private industrial			
	For livestock use			
Discharge volumes	From irrigation	1995–2005	Mm^3 (million cubic metres)	Annual
	From wastewater			
	From hydroelectricity			
	Other			
Groundwater stock volumes	Unconfined aquifers	1995–2005	Mm^3 (million cubic metres)	Annual
	Confined aquifers			
	Total groundwater			

Freshwater inflow volumes

Precipitation is the major source of inflow volumes. Measurements for the years 1995–2005 were obtained from nationwide rain gauges for the purposes of compiling Statistics New Zealand's stock account. A detailed national rainfall dataset was developed and the data was then put into a hydrological model and compiled into regional volumes (Statistics New Zealand, 2007: 11). An excerpt from the freshwater inflows dataset is shown below in figure 2 to give an indication of the context and layout of the dataset. Note that data from 1997 to 2003 is excluded below for representation purposes and that precipitation is measured below in million cubic meters (m^3).

Figure 2 Excerpt from the Freshwater Inflows Dataset

Source: SFI, 2010b

Indicator	Attribute	1995	1996	2004	2005	Data source table #
4.1 Freshwater inflow volumes[1]	Precipitation Mm³[16]	617,116.81	639,692.17	597,497.25	505,194.31	4a

Freshwater outflow volumes

Evapotranspiration, outflows to sea and net abstraction are the three attributes of freshwater outflow volumes. The Topnet hydrological model run by NIWA was used to calculate evapotranspiration, which accounts for about 20% of outflows of freshwater from New Zealand (Statistics New Zealand, 2007: 12).[4] Outflow to sea and net abstraction is a residual volume and is calculated as the inflow less other outflow and change in storage. It is the volume of water that leaves the hydrological system other than by evapotranspiration. Net abstraction is the difference between abstraction and discharges. Net abstraction is not specifically calculated because there is insufficient data on abstraction of water for irrigation, livestock use, municipal use (town water supply), private industrial use and geothermal electricity generation discharges of water back into the environment (Statistics New Zealand, 2007: 13) This is because there has been no requirement to actually measure actual water takes as distinct from what the relevant resource consent allows. A recent amendment to the RMA section 360(1)(d) enacted a National Environmental Standard (NES) requiring takes above certain stocks and flows to be measured– however it is likely to be many years before New Zealand accrues meaningful data . An excerpt from the freshwater outflows dataset is shown below in figure 3, data from 1997 to 2003 is excluded for representation purposes.

Figure 3 Excerpt from the Freshwater Outflow Volumes Dataset

Source: SFI, 2010b

Indicator	Attribute	1995	1996	2004	2005	Data source table #
4.2 Freshwater outflow volumes	Evapotranspiration Mm³[15]	112,450.79	117,443.18	116,294.28	113,274.61	4a
	Outflows to sea and net abstraction	492,955.05	507,770.01	466,026.84	392,390.34	
	Total outflows	**605,405.83**	**625,213.18**	**582,321.13**	**505,664.95**	

Change in storage volumes

[4] The Topnet hydrological model keeps daily accounts of the water balance for different catchments. See Henderson et al. (2007) for more information.

Changes in soil moisture, groundwater, snow, ice, and lake and reservoir volumes are calculated from the end of the previous June year to the end of the current June year. While the total volume of water stored by these components is large, the annual changes are relatively small (Statistics New Zealand, 2007: 15). An excerpt from the change in storage volumes dataset is shown below in figure 4, data from 1997 to 2003 is excluded for representation purposes.

Figure 4 Excerpt from the Change in Storage Volumes Dataset

Source: SFI, 2010b

Indicator	Attribute		1995	1996	2004	2005	Data source table #
4.3 Change in storage volumes	Soil moisture	Mm³	-328.36	1,600.50	-1,443.52	2,070.98	4a
	Lakes and reservoirs		-289.18	263.74	1,968.48	-3,348.06	
	Groundwater		4,220.00	-1,220.00	3,060.00	-3,130.00	
	Snow		6,218.80	13,745.71	10,626.26	2,751.27	
	Ice		1,889.72	89.04	964.91	1,185.17	
	Total change in storage		**11,710.98**	**14,478.99**	**15,176.13**	**-470.65**	

Abstraction volumes

Abstraction data reflects interactions between the hydrological cycle and the economy (Statistics New Zealand, 2007: 10). Abstraction for the purposes of hydroelectricity generation is the only component that is well documented. There is insufficient data to compile or estimate irrigation and private industrial abstraction volumes, this information will hopefully become available over the upcoming years due to the recently enacted NES regulation under the RMA requiring those to take measurement). The figures for municipal supply and domestic use (2000 and 2001 only) include domestic, commercial and industrial supply for municipal areas plus estimated domestic abstraction for households with private supply. Livestock estimates are for consumptive use, which may be only about 3% of the volume abstracted for livestock use (Statistics New Zealand, 2007: Table 15). An excerpt from the abstraction volumes dataset is shown below in figure 5, data from 1997 to 2003 is excluded for representation purposes.

Figure 5 Excerpt from the Abstraction Volumes Dataset

Source: SFI, 2010b

Indicator	Attribute			1995	1996	2004	2005	Data source table #
4.4 Abstraction volumes	For hydroelectricity generation	surface water	Mm³	181,776.18	184,534.21	166,575.09	169,850.65	4b
		groundwater		0.00	0.00	0.00	0.00	
		total		**181,776.18**	**184,534.21**	**166,575.09**	**169,850.65**	

Discharge volumes

A lack of available data means that only discharge of water for hydroelectricity generation is presented in the dataset. Water used in hydroelectricity generation is returned to the hydrological system and discharges match abstraction, meaning that 'net' abstraction is zero (Statistics New Zealand, 2007: Table 15). An excerpt from the discharge volumes dataset is shown below in figure 6, data from 1997 to 2003 is excluded for representation purposes.

Figure 6 Excerpt from the Discharge Volumes Dataset

Source: SFI, 2010b

Indicator	Attribute			1995	1996	2004	2005	Data source table #
4.5 Discharge volumes	From hydroelectricity generation	surface water	Mm³	181,776.18	184,534.21	166,575.09	169,850.65	4b
		groundwater		0.00	0.00	0.00	0.00	
		total		181,776.18	184,534.21	166,575.09	169,850.65	

Groundwater stock volumes

The groundwater volume figures were provided by GNS Science to Statistics New Zealand, and the methodology used to collect them is discussed in detail in White and Reeves (2002). Data contained in the *Water Physical Stock Account: 1995-2005* report are revised from the *Water Physical Stock Account: 1995–2001* (Statistics New Zealand, 2004b). The data was revised due to improvements made by NIWA to the national hydrological model (Statistics New Zealand, 2007:2). Groundwater levels observed in regional indicator wells were applied to the estimated level variation in the country's aquifers in order to generate estimates of annual changes in groundwater volume in New Zealand aquifers (White & Reeves, 2002: iii). An excerpt from the groundwater stock volumes dataset is shown below in figure 7, data from 1997 to 2003 is excluded for representation purposes.

Figure 7 Excerpt from the Groundwater Stock Volumes Dataset

Source: SFI, 2010b

Indicator	Attribute		1995	1996	2004	2005	Data source table #
4.1 Freshwater inflow volumes[1]	Precipitation	Mm³[16]	617,116.81	639,692.17	597,497.25	505,194.31	4a

4. Data Evaluation

In this section we evaluate the data presented in the Water Resources Dataset based on the evaluation criteria set in Table 1.

4.1 Comprehensive Time Series

Limited amount of accounting periods

The physical water stock accounts cover 11 accounting periods. The first period was 1 July 1994 to 30 June 1995, and the last was 1 July 2004 to 30 June 2005. This short time span limits the ability to analyse trends.

No recent updates

At the time our research was conducted no recent update to the 1995–2005 *Water Physical Stock Account* had been posted on the Statistics New Zealand website; however this could be work which is currently in progress.

Limited data for abstraction and discharge volumes, but good coverage of hydro electricity generation data

For abstraction and discharge volumes, only hydroelectricity generation has data available for a significant period of time. Abstraction for municipal supply and domestic use is only available for 2000 and 2001, and for livestock use there are gaps in the 1997, 1998, 2000 and 2001 accounting periods. This provides insufficient data for the identification of trends.

Insufficient data to quantify volumes of water abstracted and discharged for irrigation, livestock, private domestic use, private industrial use, and geothermal activity
Data for inflow, outflow, change in storage, and groundwater stock volumes are well documented and consistent throughout the period 1995–2005. However, as a whole, the dataset is lacking in many areas. In particular there are gaps in the stock accounts concerning water use by people and livestock (abstraction and discharge volumes). Where possible, volumes have been estimated and are included in the dataset; however, there was insufficient data available to quantify the volumes of water abstracted for irrigation, livestock, municipal use, private industrial use, and geothermal activity. These gaps are put down to a lack of comprehensive data and inaccurate estimation methods (Statistics New Zealand, 2007: 2). However, this lack of data is also attributable to the lack of requirement (until the recently enacted Resource Management (Measurement and Reporting of Water Takes) Regulations 2010) on abstractors of water to actually measure what they abstract and therefore no data has been collected.

4.2 Quality Data

Hydrological modelling used to estimate values
A lot of the figures represented in the dataset are estimated values derived from a hydrological model. Where possible, margins of error have been calculated and made available in corresponding reports. New research and adjustments made to the hydrological model by NIWA improved the accuracy of the 1995–2001 data, and the results contained in the 1995–2005 account were revised (Statistics New Zealand, 2007:2). Further improvements will be needed on estimates of rainfall, particularly in high-rainfall areas, and on actual evaporation throughout New Zealand, to improve the accuracy of the accounts (Henderson et al., 2007: iv). The values provided will therefore be as good as the numerical models used for the analysis.

Includes inland components of the hydrological cycle only
The water accounts prepared by Statistics New Zealand deal with the inland water component of the hydrological cycle. The scope is broad, including all freshwater resources (as opposed to seawater), whether above, on or below ground, that provide both direct use and non-use benefits (Statistics New Zealand, 2004: 13).[5]

Regional datasets available for more meaningful analysis

[5] 'Direct use benefits include water that can be extracted in the current period as well as water that may be of use in the future. Non-use benefits (such as kayaking) arise simply by having the resource exist.' (Statistics New Zealand, 2004: 13)

The water stock accounts are compiled on a regional as well as a national basis, which enables variations in precipitation and water availability in different areas to be identified. For example, there may be droughts in Canterbury while there are heavy rainfalls on the West Coast (Statistics New Zealand, 2004a: 14). Since such extremes tend to average out at the national level, and due to the scope of this project, the Institute has opted to present only the national statistics in its dataset, however regional accounts may be necessary for meaningful analysis. Regional volumes are recorded in the annual tables included in the *Water Physical Stock Account: 1995-2005* (Statistics New Zealand, 2007: 9).

Comprehensive national level data for hydroelectricity abstraction and discharge volumes
Abstraction and discharge of water for hydroelectricity generation involves large volumes of water. The volumes of water recorded in the stock account are presented at the national level, and it is noted that water abstracted or discharged by one power station may also have been abstracted or discharged by another upstream. Hydroelectricity generation is a non-consumptive use of water, thus the abstraction volumes in the dataset equal the discharge volumes. Therefore it is not of any specific use for this project, other than to inform on how important it is for electricity generation.

Well documented changes in storage volumes
Change in storage volumes are well documented throughout the accounting period; however it is worth noting that the total volume of water stored in the different components is large, but the annual changes are much smaller. Statistics New Zealand reports that annual absolute changes in storage averaged less than 1% of precipitation for the June years 1995 to 2005 (Statistics New Zealand, 2007: 15).

Limitations for estimating groundwater storage and volumes
It is unlikely that all groundwater aquifers were identified by GNS Science for the purposes of the water stock account. There may also be errors in the estimated areas and volumes of some of the aquifers. To calculate the volumes, the average height was multiplied by the area (i.e. assuming the aquifer was a 'slab'); however in reality the depth of an aquifer will vary at different points. Similar limitations exist for changes in volume.

4.3 Appropriate Sources

Data collection by NIWA and GNS
Statistics New Zealand commissioned NIWA to estimate 10 of the components presented in the *Water physical stock account*. NIWA used three main methods to collect and estimate the different stock volumes: direct calculation from measurements; spatial mapping, and simulation modelling (Henderson, et al, 2007: IV). Statistics New Zealand specified July 1 to June 30 as its accounting year. GNS Science also has water monitoring networks which contributed to the groundwater stock accounts.

The involvement of NIWA and GNS in the stock accounts ensured that scientific methods were used in developing the research programmes, collecting, compiling and analysing the data.

4.4 Public Availability

All data publicly available and well documented

It is the aim of this project to assess publicly available data, i.e. data that is able to be accessed by parties independent of those who collect or present it. Statistics New Zealand's reports fit this criterion; the reports are freely available to the public via the agency's website.

Variable regional council policies for accessing data

Under the Resource Management Act 1991, regional and district councils are delegated the role of managing a large proportion of New Zealand's freshwater and coastal water. Access to data can be difficult because not all councils adopt the same policy regarding accessibility and sharing of information. For example, estimates for municipal and domestic abstraction are not included in the account, one of the reasons being that some councils have constraints on what resources they can openly supply (Statistics New Zealand, 2007: 16).

5. Summary Evaluation of the Dataset

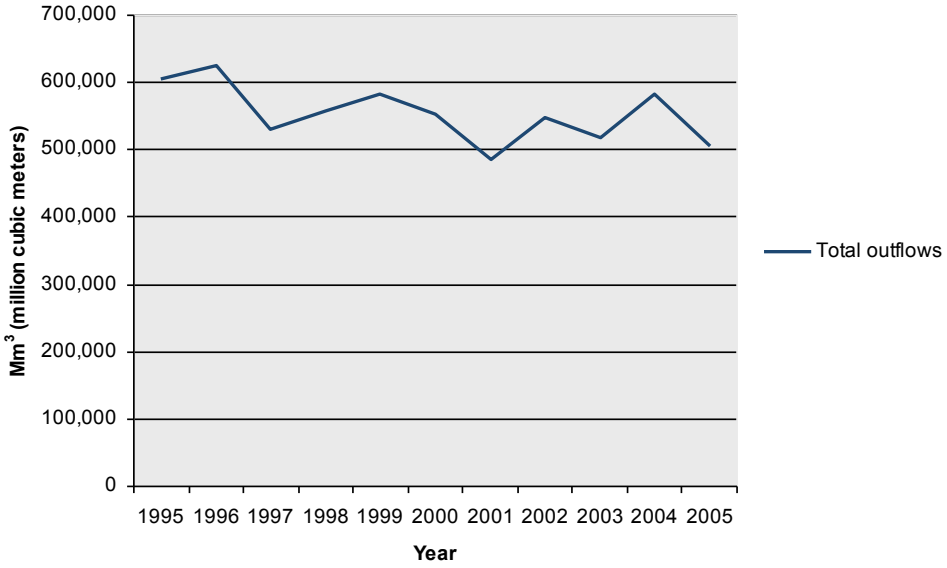
The Institute chose the Statistics New Zealand's *Water Physical Stock Account* as the primary source of data to inform its upcoming Report 10 and a NSDS as it was the first comprehensive, complete and publicly available dataset of this kind produced for New Zealand. However the physical stock accounts have certain limitations, especially in regards to the lack of information for abstraction volumes other than for hydroelectricity. Table 3 below summarises the Institute's evaluation of the dataset.

Table 3 Summary of Water Resources Data Evaluation

	Strengths	Weaknesses
Comprehensive time series	▪ Consistent records and methodologies used for the 11 accounting periods ▪ Good coverage of hydroelectricity generation data for abstraction and discharge volumes ▪ Single source of information via the Statistics New Zealand *Water Physical Stock Account*	▪ Limited number of accounting periods. Data only spans over 11 years. ▪ No recent updates. Last record available is 2005. ▪ Insufficient data to quantify volumes of water abstracted and discharged for irrigation, livestock, municipal use, private industrial use, and geothermal activity ▪ Lack of historical data prior to 1995, with data also lost in Government reforms
Quality Data	▪ Consistent methodologies and modelling techniques used across the dataset ▪ Regional datasets available for more meaningful analysis ▪ Comprehensive national level data for hydroelectricity abstraction and discharge volumes ▪ Well documented changes in storage volumes	▪ Hydrological modelling used to estimate values. Data is as good as the numerical models are. ▪ Includes inland components of the hydrological cycle only. Seawater accounts not considered. ▪ Limitations for estimating groundwater storage and volumes ▪ Lack of abstraction/discharge data
Appropriate Sources	▪ Data collection by NIWA and GNS ensured scientific methods were used in the research programmes, collecting, compiling and analysing the data	▪ Lack of easy public access on water data held by regional councils and other CRIs such as ESR.
Publicly available	▪ Statistics New Zealand's *Water Physical Stock Account* publically available	▪ Variable regional council policies for accessing data

The Institute acknowledges that other sources may need to be consulted in order to gain a comprehensive overview of water resources in New Zealand. The Institute's dataset does not answer the questions outlined in Section 1.3, but can provide background statistics to support reporting analysis and argumentation can. An example of how the data may be used is presented in Figure 8.

Figure 8 Total Freshwater Outflow Volumes 1995 to 2005
Adapted from SFI, 2010b



Glossary

Source: Statistics New Zealand, 2007: 27–28

Glossary	
Abstraction	The taking of water from groundwater or surface water resources.
Aquifer	A permeable water-bearing geological formation capable of yielding exploitable quantities of water.
Evapotranspiration	Transfer of water from the earth's surface to the atmosphere by evaporation of liquid or solid water plus transpiration from plants and animals.
Freshwater	Naturally occurring water having a low concentration of salts.
Groundwater	Subsurface water occupying the saturated zone (in which all voids, large and small, are filled with water). Excludes soil moisture.
Precipitation	Water in any form (including rain, snow, hail, sleet and mist) that leaves the atmosphere and reaches the Earth's surface.
Surface water	Water that flows over or is stored on the ground surface.

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