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Cost–benefit Analysis for a National Environmental Standard for Water Measuring Devices

Prepared for the Ministry for the Environment

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Cover pictures, clockwise from left: Lateral move irrigator, installation of electromagnetic measuring devices, installation of mechanical measuring device.

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EXECUTIVE SUMMARY

In April 2006 the Minister for the Environment and the Minister for Agriculture and Forestry jointly released the Sustainable Water Programme of Action. This programme includes a range of actions, one of which is to prepare a national environmental standard (NES) for methods and devices for measuring actual water taken. The aim of the proposed NES is to ensure the accurate and comprehensive measurement of water takes to facilitate the sustainable management of New Zealand's water resource. It would do this by:

- setting the minimum requirements for all new water-measuring devices that are installed
- defining situations where water measuring devices are compulsory.

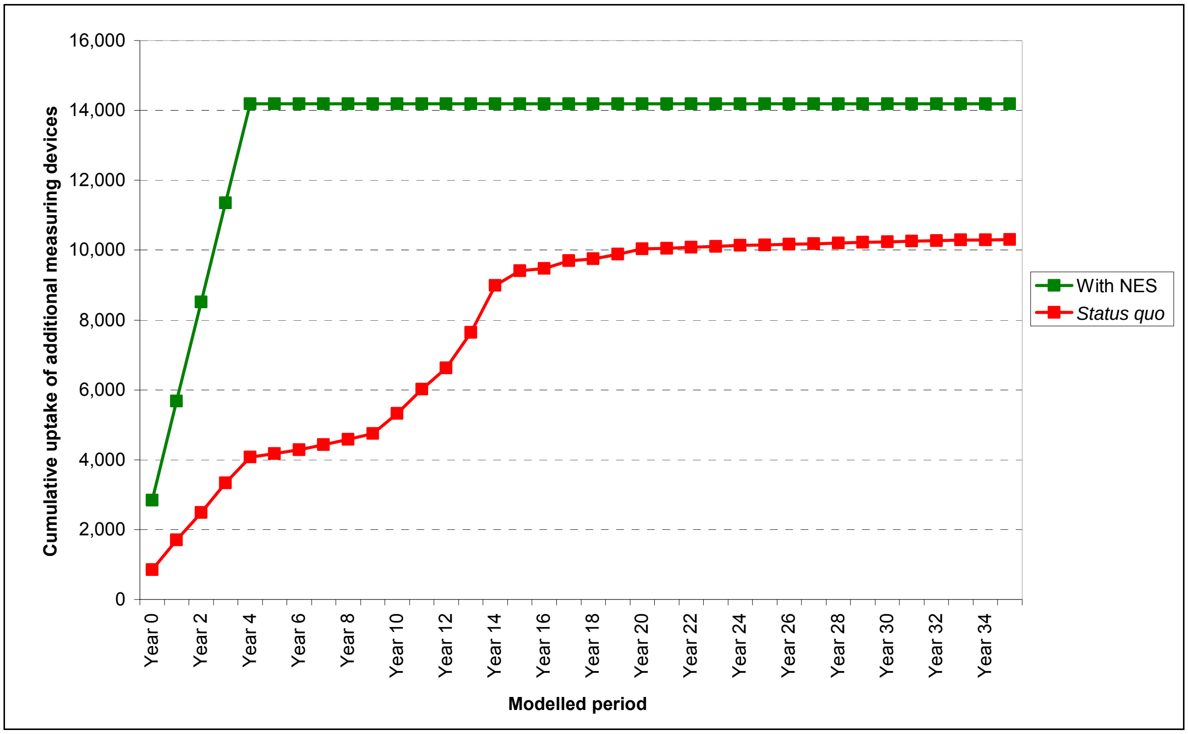
The NES would apply to those who have obtained, or are seeking to obtain, a resource consent for abstracting water. Four scenarios for the uptake of water measuring devices have been considered:

- the status quo
- the proposed NES
- national direction through voluntary approaches and working with regional councils without regulation
- legislative change (via amendment of the RMA).

Our analysis has shown that, of these options, only the NES is able to achieve the policy objectives. Specifically, it is the only option that provides for the consistent, accurate and comprehensive measurement of consented abstraction in a timely and cost-effective manner.

The status quo would result in around 10,300 water-measuring devices being installed over a 36-year period. The proposed NES would result in approximately 14,200 water-measuring devices being installed over a five-year period, subsequent to the gazetting of the regulation. The differences in cost and benefits between the NES and the status quo are largely associated with the differences in the extent to which measuring devices are required and the timeframe for consents to include a water measuring device (see Figure 1).

Figure 1: Uptake of water measuring devices under the status quo and proposed NES



The present value ($PV_{10\%}$[1]) of the capital, ongoing, replacement and consent review costs of the proposed NES relative to the status quo is estimated at $42.3 million. The additional cost of the implementation package proposed by the Ministry for the Environment adds approximately $1.2 million to the total cost, taking the total up to $43.5 million. Ninety-six percent ($41.8 million) of the cost would be incurred by existing consent holders, while regional councils and central government would incur 3 percent ($1.1 million) and 1 percent ($0.6 million) of the cost, respectively.

Following are a number of important benefits from having an NES.

- There is almost universal agreement among stakeholders that the measurement of consented water take will help improve the management of New Zealand's freshwater resource. The potential for this kind of improved management is delayed under the status quo. Existing studies indicate that New Zealand residents place high value on the protection of the natural environment, and on this basis it is reasonable to assume that improvements in the management of freshwater resources and environmental flows will be accorded a high value by New Zealand residents.

- Compliance monitoring and enforcement will be improved. In the absence of water-measuring devices this is so imprecise and inaccurate as to only be useful for blatant non-compliance, such as that occurring during times of restriction.

[1] $PV_{10\%}$ – present value, discount rate 10%

- Confidence in water resource management will be improved by the measurement of consented water take, and improved public confidence may result in reduced transaction costs in resource consent decision-making.

- The proposed NES will improve the ease and effectiveness with which actual water take can be reported. Measuring actual water take is important for achieving and demonstrating improved efficiency at all levels (individual, industry, regional and national). At the national level the proposed NES will allow complete physical water accounts to be compiled within five years of the regulation being gazetted. This will assist the understanding of the effects of environmental policy on the economy, and of economic policy on the environment. It will also help New Zealand to meet its international obligations to report the status of and changes to its natural environment.

- Technical efficiency gains for existing consent holders from the enhanced monitoring and management of systems performance have not been quantified. However, stakeholder interviews and the literature suggest that there can be benefits from consented water users monitoring the actual water taken, which in some situations may offset the cost of installing and maintaining a water-measuring device.

- There is the potential for water allocation to be made more efficient from knowing just how much water has been taken − although this benefit only occurs where water is scarce. In the absence of data on the actual take, determining the reasonable needs of consented water users is based on relatively simple models, and allocation is often based on these same models. Hence, the availability of data describing actual take will allow for fairer and more efficient allocation through:

  - identification of un-utilised allocation
  - refinement of estimates of the degree of effective catchment allocation
  - improved resource understanding, allowing for less conservatism in the setting of allocated volumes at the catchment level.

- Aqualinc estimate that knowledge of actual water take has the potential to free up to 5 to 10 percent of the allocated volume in what are considered to be highly allocated regions.[2]

The quantitative benefits arising from allocative efficiency gains can be estimated for a scenario in which irrigators are able to have an increased level of consumption. The potential benefit to future and/or current irrigators illustrates the magnitude of the potential benefit (Table 1). Note that the level of benefit identified is illustrative only, and cannot be

[2] John Bright, Aqualinc Research Limited, personal communication, July 2007.

attributed solely to the installation of water measuring devices: the implementation approach taken will also be critical. The allocative efficiency benefit enabled by the proposed NES results from the benefit arising earlier than it otherwise might.

Table 1: $PV_{10\%}$ of potential benefit resulting from improvement in allocative efficiency ($million)

Level of increase in water consumption take for irrigation through improved allocative efficiency in highly allocated regions	**2.5%**	**5.0%**	**7.5%**
$PV_{10\%}$ benefit arising from improved allocative efficiency ($million)	$31.8	$63.6	$95.5

The results suggest that if the installation of water-measuring devices enables a 3.4 percent increase in consumption for irrigation in what are currently considered highly allocated regions, the benefits will outweigh the costs of the proposed NES. The benefit illustrated would accrue to existing irrigators able to exploit the knowledge that they are not fully utilising their consented allocation (e.g. through increasing their irrigable area), or to potential irrigators seeking consents in catchments that are considered to be highly allocated. The increased use of water may, however, have some offsetting costs in terms of in-stream values, water quality and green-house-gas emissions due to the intensification of land use.

Although this shows the potential for allocative efficiency gains to allow an increase in water consumption by irrigators, the efficiency gains may also be enjoyed by others, including municipal water supplies and industrial users. Allocative efficiency gains could equally occur as environmental flows, that is, the amount of water taken from the water body is reduced. Under this scenario, councils will have determined that the value of water as environmental flows is equal to or greater than its value as consumptive use.

Table 2 provides a summary of the costs and benefits identified, along with an indication of their magnitude.

Table 2: A summary of the magnitude of costs and benefits of the NES

			Magnitude	Affected group
Cost	$PV_{10\%}$ cost of NES	Quantified	$41.8 million	Existing consent holders
			$1.1 million	Regional council
			$0.6 million	Central government
	Total $PV_{10\%}$ Cost of NES		**$43.5 million**	
Benefit	Management of freshwater resources	Qualitative	Improved	Regional council and the wider regional community
	Determination of environmental flows	Qualitative	Improved	Regional council and the wider regional community
	Compliance monitoring	Qualitative	Significantly improved	Regional council, consent holders and the wider regional community
	Transaction costs at consent application	Qualitative	Possible reduction	Regional council, consent applicants and the wider regional community
	Technical efficiency	Qualitative	Can provide benefit in some situations	Consent holders
	Allocative efficiency	Quantified	Significant (e.g. if it enabled a 3.4% increase in water consumption by irrigation, the benefits would outweigh the costs of the NES)	Applicants for new consents and existing consent holders, where the latter are able to exploit the knowledge that they are not fully utilising their consented allocation
	Reporting and understanding actual water take	Qualitative	Significantly improved	Regional council, central government, consent holders and consent applicants

Several regional councils and other parties have submitted that regional councils should maintain discretion as to when and where measuring devices are required. They argue that there is little benefit in requiring measurement in regions/catchments where consented abstraction is a small proportion of the total available resource. Some councils have suggested that small takes should only require measurement where a resource is highly allocated, or where the cumulative effect of smaller takes is significant.

On a national basis it is estimated that 44 percent of the cost ($PV_{10\%}$ cost $19 million) of the NES is associated with take rates of less than 10 L/s, and that these takes account for 4 percent of the total unmeasured annual allocation by volume. The large proportion of cost (34 percent) associated with takes of less than 5 L/s arises because of the large number of consents and the assumption that under the status quo currently unmeasured takes of this size are exempt by many councils from the requirement to instal measuring devices. Approximately 57 percent of cost is associated with the measurement of takes of less than

20 L/s. These takes account for just 8 percent of the estimated unmeasured annual allocation.

Submissions and key informant interviews have repeatedly raised doubts that the industry can install approximately 14,200 water measuring devices over a five-year period. If the proposed timeframe for achieving comprehensive measurement of consented water takes were extended to 10 years following gazetting of the regulation, the $PV_{10\%}$ cost would be reduced by 34 percent − from ≈$43.5 million to ≈$28.6 million.

1 BACKGROUND

In April 2006 the Minister for the Environment and the Minister for Agriculture and Forestry jointly released the Sustainable Water Programme of Action. The programme includes a range of actions, one of which is to prepare a national environmental standard (NES) for methods and devices for measuring actual water take. In December 2006 a discussion document on the proposed NES was released for public submission. This document sets out the rationale for measuring water take and for developing a standard, how a standard would provide national consistency, and the aims of the standard.

The discussion document proposed the introduction of an NES, with the aim of ensuring the accurate and comprehensive measurement of water takes to facilitate the sustainable management of New Zealand's water resource. The specific objectives which the proposed NES seeks to achieve are to:

- ensure consistency at the national, regional and catchment levels for measuring and reporting actual water taken
- enable water users and regulators to easily determine compliance with water take consents
- provide accurate information about the actual water taken in any catchment
- ensure the comprehensive uptake of water-measuring devices in a cost-effective and timely way.

The proposed NES will achieve this by setting the minimum requirements for all new water-measuring devices installed, and by defining situations where water-measuring devices are compulsory.

National environmental standards are legally enforceable regulations under sections 43 and 44 of the Resource Management Act 1991 (RMA). The proposed NES constitutes a minimum standard, with regional councils retaining the authority to set more stringent requirements in their regional plans.

As part of finalising an NES, the Ministry for the Environment must supply a section 32 analysis and a regulatory impact analysis. To satisfy these requirements, the Ministry commissioned a cost–benefit analysis which:

- sets out, discusses and assesses the benefits and costs of the proposed NES and gives an indicative range of the likely present value of the benefits and costs
- apportions the costs to parties
- presents the assessment of costs and benefits in a final report.

The Ministry for the Environment commissioned Harris Consulting to undertake this analysis.

2 CONSIDERATION OF ALTERNATIVES

Section 32 of the RMA requires the proposed course of action to be compared with alternative courses of action, including the status quo, and consideration of the extent to which the different alternatives are likely to be effective in achieving the objectives. This section describes the alternatives and makes an assessment of their likely effectiveness in achieving the objectives of the proposed NES.

Four scenarios for the uptake of water-measuring devices by consented abstractors have been considered. These are:

- the status quo
- the proposed NES
- voluntary approaches and working with regional councils without regulation
- legislative change (via amendment of the RMA).

Each alternative is discussed below and assessed for its ability to meet the policy objectives.

2.1 Option 1: Status quo

Status of water-measuring devices in regional planning

The status quo scenario forms the basis of any cost−benefit analysis. The preliminary cost−benefit analysis conducted as part of the discussion document defined the status quo as:

> *... the water measurement regime in the absence of the proposed National Environment Standard, comprising:*
> - *regional councils' current and planned future policies on water measurement, including the obligations placed on consent holders*
> - *consent holders' current and future voluntary installation of meters and measurement of their water use for their own information.* (Ministry for the Environment, 2006)

Aqualinc's stocktake of existing water-measuring devices suggests that there are 19,527 consented water takes nationally, of which 66 percent (or 12,850 takes) are unmeasured. This means that of an estimated total annual allocated volume of 9,908 million cubic metres, approximately 69 percent (6,800 million cubic metres) is not currently subject to measurement.[3] The following table summarises the extent to which regional councils

[3] Unless otherwise stated, all values describing the number of consents, take rates, estimated annual allocation, currently installed measuring devices, time to expiry, etc. have been taken from the water allocation consent database provided by the Ministry for the Environment and prepared by Aqualinc Research Ltd.

currently measure consented water take, along with any proposed measures to introduce measuring devices.

Table 3: Current status of water measurement by region

Council	No. of consents	No. of devices (% of consents)	Current practice
Northland	606	141 (23%)	Measurement is done in areas of high allocation, including both surface- and groundwater. Measurement requirements are detailed in the regional plan (rule 25.3.1) for groundwater takes. There are no specific rules for surface-water metering, but the standard condition is as per groundwater. The rule does not require data loggers, nor does it specify a maintenance schedule. The frequency of recording varies depending on the potential effects.
Auckland	1,420	1,420 (100%)	All consented takes require measurement, and the take is monitored. Measuring requirements are detailed in the regional plan for surface-water and groundwater takes (rules 6.5.11−6.5.35). Levels of accuracy and reporting requirements are specified.
Environment Bay of Plenty	1,127	176 (16%)	BOP are moving to the measurement of all water takes. Measurement is required under the Proposed Regional Water and Land Plan in areas where there are significant pressures, small flows or high ecological/cultural values, or where the take is for a municipal supply.
Environment Waikato	787	394 (≈ 50%)	The regional plan requires measurement of all consented takes. Regional Plan − Water Allocation Policy 11 details the requirements of measurement, including levels of accuracy and reporting.
Gisborne District Council	161	161 (100%)	All takes are measured. At the start of the season consent holders fax in a copy of what they are using and must continue to do this every two weeks.
Taranaki Regional Council	186	153 (82%)	Consent conditions require measurement. Many users have data loggers sending information to the council.
Horizons Regional Council	552	130 (23%)	As water management plans come into force, all significant existing users will be required to measure take and be telemetered. The aim is to have 80% of takes telemetered. HRC is requiring flow-meters and telemetry on all significant consents as they come up for replacement, and also on all significant new consents.

Council	No. of consents	No. of devices (% of consents)	Current practice
Hawkes Bay Regional Council	2,517	354 (14%)	Consented groundwater takes must meet threshold volumes. New consents > 2500m^3/week and existing takes > 5,000m^3/week, upon replacement are required to measure take. Surface-water takes require measurement where a river has a defined allocatable volume, where the take is for industrial purposes, or where there is evidence of increasing demand from a surface-water body for which there is insufficient information. Requirements detailing the level of accuracy are given in the regional plan, along with the timing of implementation. For existing surface-water takes meeting the above criteria, measuring devices are to be installed upon replacement, or within 3 years of the plan becoming operative, whichever occurs first. For existing groundwater takes meeting the above criteria, meters are to be installed upon replacement, but with a minimum lead-in time of 3 years from the date the plan becomes operative.
Greater Wellington	677	260 (38%)	Takes greater than 20 L/s are typically measured. Smaller takes are subject to measurement where resource characteristics and demand require it. Details are not provided in the plan.
Marlborough District Council	1,191	800 required (67%)	Measurement is standard practice now, but many areas were not measured historically. New areas/takes are measured, but not old takes. This is being addressed through consent replacement. The actual number of measuring devices may be less than that reported.
Nelson City Council	33	Unknown	All urban water users (to individual connections) are metered and charged on a volumetric basis. Following the operative date of the plan change, measuring devices will be required to be installed for all new and existing consented abstractions, and 3-monthly records are required to be kept by consent holders. Levels of accuracy and reporting requirements are specified.

Tasman District Council	1,319	623 (47%)	All users are measured in high-demand areas. Measurement in all catchments that are moving towards full allocation. Measurement requirements are detailed in the Tasman Resource Management Plan.
West Coast Regional Council	432		The measuring volume of surface-water takes is provided for in the regional plan, but this is under appeal. The WCRC does not consider measurement of all takes to be necessary in their region as there is very little demand pressure on an abundant regional water resource.
Environment Canterbury	5,872	642 (11%)	All new consents, including replacement consents, require measuring devices of defined accuracy and are required to measure/record the take. Measuring devices are being included in consent review processes (e.g. Rakaia−Selwyn) and will be required under an operative Natural Resources Regional Plan.
Otago	1,968	984 (≈ 50%)	The requirement for measuring devices is standard, telemetered in some catchments, datalogged in others. Telemetry is working well. The application and accuracy of measurement are reported as being an ongoing issue.
Environment Southland	679	445 (66%)	Take consents are generally measured, but the requirements are largely related to average use rather than daily totals. The regional plan mentions measurement requirements, but no standards are given.

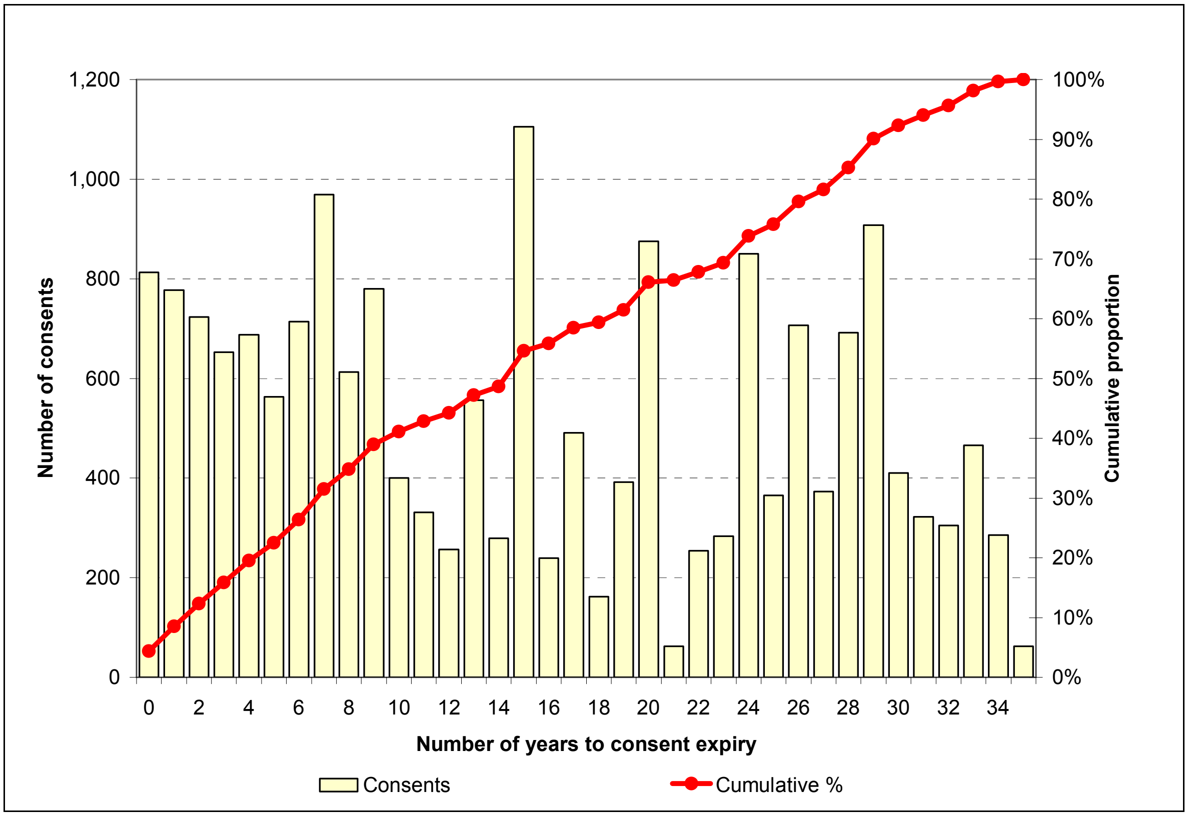
Sources: Aqualinc, 2006b; Ministry for the Environment table of regional council policy; key informant interviews; and regional plans including ARC 2005, Ecan 2007a, EnvWaikato 2006, and Northland 2004.

Only three councils have implemented the universal measurement of consented water take. Aquilinc (2006b) note that "one of the reasons other councils have not implemented universal water measurement is that use monitoring is often not required on existing consents". A further reason given during key informant interviews is that measuring actual water take may be unnecessary in situations where there is ample water resource to meet demand, and where consented take has little or no impact on the resource.

In many cases councils are planning to add the condition for the measurement of actual water take to new consents and upon consent replacement. This condition is unlikely to be universal, however, with smaller consented takes and catchments without prescribed allocative limits exempt from measurement. It is clear that even where councils have implemented − or propose to implement − measurement there is significant variation in the detail and extent to which the required accuracy and reporting standards for metering are prescribed, as well as significant variation in the conditions under which metering is required.

A further barrier to the uptake of water-measuring devices under the status quo stems from the fact that about 35 percent of consents have a replacement date of 20 years or more (see Figure 2). The majority (85 percent) of these long-term consents are in the Canterbury region.

Figure 2: Consent expiry dates



Source: Ministry for the Environment's consents database, compiled by Aqualinc (2006c)

Environment Canterbury (ECan) has initiated consent review processes that are likely to see measuring devices installed on consented takes in key aquifers within five years. ECan's proposed Natural Resources Regional Plan (NRRP) includes the universal measurement of consented water takes. It is anticipated that this plan will be operative within five to six years, and that universal measurement of consented water takes will be achieved within 10 years of the plan becoming operational.[4]

[4] Mike Freeman, Director Regulation, Environment Canterbury, personal communication, July 2007.

Key informant interviews suggest that the voluntary installation of water-measuring devices is occurring ahead of consent requirements. The extent to which this is taking place is unknown, but it is not considered to be widespread and is unlikely to result in the consistent, accurate and comprehensive measurement of consented water take within the policy's desired timeframe.

Table 4 summarises the advantages and disadvantages of the status quo, and Table 5 compares the status quo with the objectives of the proposed NES.

Table 4: Assessment of the advantages and disadvantages of the status quo option

Advantages	Disadvantages
The status quo option: • is simple • is inexpensive • matches the decentralised approach to resource management, allowing local solutions.	• It does not ensure consistent, accurate and comprehensive measurement of the actual take. • The uptake of measuring devices will be significantly delayed and may not occur at all in some catchments/regions.

Table 5: Assessment of the status quo against the objectives

Policy objective		Does this option meet this objective?
Objective (i)	Ensure consistency at national, regional and catchment levels for the measuring and reporting of actual water taken.	No – it does not ensure consistency, because implementation will vary between regions and the installed devices may have various accuracies, verification standards etc.
Objective (ii)	Enable water users and regulators to easily determine compliance with water take consents.	No – regional ability to monitor and report compliance will vary with the implementation approach.
Objective (iii)	Provide accurate information about actual water taken in any catchment.	No – some catchments may be subject to comprehensive and accurate measurement but others will not.
Objective (iv)	Ensure the comprehensive uptake of water-measuring devices in a cost-effective and timely way.	No – although cost-effective, uptake is unlikely to be timely.

The status quo appears unlikely to fulfil the policy objectives of consistent, accurate and comprehensive measurement of consented water take. Although the objectives might be achieved under the status quo, it appears highly unlikely they could be achieved within the policy's stated timeframe of five years after the gazetting of the regulation. The status quo does, however, have the advantage of being low cost and requiring no new regulation.

2.2 Option 2: Introduce a national environmental standard

The proposed NES is concerned with ensuring that all consented water takes are subject to continuous measurement. The NES proposes that new consents will be immediately subject to the regulation, and that the measurement of existing consents will be achieved within five years of gazetting the regulation. It is also proposed that no consented water takes be exempt from the standard.

The requirements of the standard are given as follows.

> ***Minimum requirements for water measuring devices***
> *It is proposed that all new pipe-measuring devices installed after the National Environmental Standard is enacted:*
> - *be capable of continuous measurement*
> - *measure volume in cubic metres*
> - *have an accuracy standard of ± 5%*
> - *be capable of recording daily volume*
> - *be fit for purpose*
> - *be tamper-proof and sealed.*
>
> *It is proposed that all new channel measuring devices installed after the National Environmental Standard is enacted:*
> - *continuously measure water levels*
> - *have a water level accuracy of ± 10mm*
> - *maintain a rating curve to convert water levels to flow*
> - *fit a data logger to store the water-level data.*
>
> ***Installation and maintenance requirements for water measuring devices***
> *It is proposed that:*
> - *installation of water measuring devices is required as a condition of a water take consent*
> - *installation should strictly comply with the manufacturer's installation instructions*
> - *measuring devices should be installed as close as possible to the take point, and before the first outlet point*
> - *the accuracy of all measuring devices must be independently verified every five years.*
>
> ***Data recording and transfer requirements for water measuring devices***
> *It is proposed that:*
> - *responsibility for recording the water measurement rests with the consent holder*
> - *responsibility for transferring the data to the regional council rests with the consent holder and should occur on at least an annual basis*
> - *data recording should occur at a minimum of daily intervals.*
>
> (Ministry for the Environment, 2006)

The Ministry for the Environment has provided clarification that data loggers are *not* required on piped or channel takes as long as the alternative recording system is capable of being audited and checked. They have also confirmed that the accuracy requirement for channel takes is now defined as 10 percent of flow.

The NES provides a relatively simple and effective way of introducing requirements for councils to add conditions to existing and new consents to ensure the consistent, accurate and comprehensive measurement of a water take. Table 6 summarises the advantages and disadvantages of the proposed NES, and Table 7 assesses its ability to meet the regulation's objectives.

Table 6: Assessment of the advantages and disadvantages of the NES option

Advantages	Disadvantages
• Simple for central government to implement. • Provides certainty for consent holders and applicants. • Provides regional councils with certainty as to the required actions when considering consents. • Will achieve consistent, accurate and comprehensive measurement of consented water takes.	• Does not allow local decision-making on when and where to measure the water take. • It is an additional piece of regulation which must be considered.

Table 7: Assessment of the proposed NES against the objectives

Policy objective		Does this option meet this objective?
Objective (i)	Ensure consistency at national, regional and catchment levels for the measuring and reporting of actual water taken.	Yes
Objective (ii)	Enable water users and regulators to easily determine compliance with water take consents.	Yes
Objective (iii)	Provide accurate information about actual water taken in any catchment.	Yes
Objective (iv)	Ensure the comprehensive uptake of water-measuring devices in a cost-effective and timely way.	Yes – the proposed regulation requires that measuring devices are installed within 5 years of gazetting.

2.3 Option 3: National direction through voluntary approaches and working with regional councils without regulation

In this approach the Ministry for the Environment would work alongside regional and user groups to facilitate the measurement of consented water takes. A range of technical assistance would be offered, but there would be no compulsion for regions to implement a regime.

It is likely that this approach would be reasonably successful in that many councils already recognise the importance of measuring actual water take. However, funding constraints and differing priorities would mean that implementation was inconsistent throughout the country, and this option does not provide a clear mandate for councils to take action.

Table 8 summarise the advantages and disadvantages of voluntary approaches, and Table 9 compares these approaches with the objectives of the proposed NES.

Table 8: Assessment of the advantages and disadvantages of voluntary approaches and working with regional councils

Advantages	Disadvantages
• Keeps regulatory complexity to a minimum. • Allows for local decisions on trade-offs between objectives.	• Achieves some control of measurement standards, but these will vary across regions. • Does not ensure comprehensive and accurate measurement of the actual water take. • Does not give regional councils certainty as to the actions to take. • There is less certainty for consent holders and applicants.

Table 9: Assessment of voluntary approaches and working with regional councils against the objectives

Policy objective		Does this option meet this objective?
Objective (i)	Ensure consistency at national, regional and catchment levels for the measuring and reporting of actual water taken.	No – the actual implementation will vary between regions.
Objective (ii)	Enable water users and regulators to easily determine compliance with water take consents.	No – the regional ability to monitor and report compliance will vary with implementation.
Objective (iii)	Provide accurate information about actual water taken in any catchment.	No – some catchments may be subject to comprehensive and accurate measurement but others will not.
Objective (iv)	Ensure the comprehensive uptake of water-measuring devices in a cost-effective and timely way.	No – uptake is unlikely to be timely.

2.4 Option 4: Legislative change − RMA amendment

The RMA could be amended to ensure the measurement of consented water take.

Section 35 of the Act gives a council the responsibility to monitor "the exercise of the resource consents that have effect in its region or district, as the case may be, – and take appropriate action (having regard to the methods available to it under this Act where this is shown to be necessary" (section 35(2)(d)). It is evident from Aqualinc's (2006b) stocktake of water measuring that although councils are individually exercising this duty to a greater or lesser extent, the level of monitoring is not commensurate with the comprehensive measurement of consented water take envisaged in the proposed NES.

A variety of sections of the RMA could be amended to achieve comprehensive measurement of consented water take, such as section 108: Conditions of Resource Consents. An amendment to this section would have the effect of requiring water take consents to be subject to continuous measurement, with a schedule defining the required measurement and reporting standards. Such a change would inform new consents and affect existing consents at their replacement. It might also result in the need for changes to some regional plans, which can be an expensive and time-consuming process.

The legislative approach would elevate the need to measure consented water take to a special status. This would be somewhat anomalous, as the RMA does not specifically define the need or standards for the measurement of any other environmental services.

The RMA allows NES provisions to apply to existing consents. The nature of any regulation is not as clear under legislative change in terms of requiring existing consents to measure actual water take with any immediacy. This lack of clarity arises because it is unusual for legislative change to be applied retrospectively. Under this option, the timeframe envisaged by the proposed NES for achieving the consistent, accurate and comprehensive measurement of consented water take is unlikely to be achieved.

Table 10 summarises the advantages and disadvantages of legislative methods, and Table 11 compares these methods with the objectives of the proposed NES.

Table 10: Assessment of the advantages and disadvantages of the RMA amendment option

Advantages	Disadvantages
• Provides regional councils with clear guidance on the required actions. • Keeps regulatory complexity to a minimum.	• It is unclear how this would apply to existing consents, and therefore comprehensive measurement would not be achieved in the timeframe given in the proposed NES. • It would be anomalous in terms of the Act.

Alterations to legislation are likely to be more expensive and time-consuming than the NES option. However, altering the RMA may have the advantage that regional plans would need to be more specific in relation to defining the need and standards for measuring consented water take.

Table 11: Assessment of amendments to the RMA against objectives

Policy objective		Does this option meet this objective?
Objective (i)	Ensure consistency at national, regional and catchment levels for the measuring and reporting of actual water taken.	Yes
Objective (ii)	Enable water users and regulators to easily determine compliance with water take consents.	Yes
Objective (iii)	Provide accurate information about actual water taken in any catchment.	Yes
Objective (iv)	Ensure the comprehensive uptake of water-measuring devices in a cost-effective and timely way.	No – it is unclear whether legislation would require existing consents to measure actual water take, and therefore the uptake of measuring devices would be delayed.

2.5 Summary of options

It appears that, of the options discussed above, only the proposed NES is able to achieve the policy's objectives. Of the other options outlined, a legislative amendment to the RMA comes closest to meeting the objectives of the proposed NES. However, it is likely that such amendment would take significantly longer to gazette.

3 COSTS AND BENEFITS OF THE PROPOSED NES

The costs and benefits of the proposed NES will depend on how much it changes the status quo. Costs will typically be incurred as a result of increased activity, although in some cases there will be no increased costs because councils and consent applicants are already taking the steps required by the proposed NES.

3.1 Identification of costs and benefits

Table 12 details the costs and benefits identified in the discussion document, along with further benefits identified by Harris Consulting, arising from the proposed NES. Where quantitative measures of cost and benefit can be made, these are reported. Other costs and benefits are discussed in qualitative terms, with quantitative data to support the discussion.

Table 12: Cost and benefits of the proposed NES

Affected group	Costs	Benefits
Consent holder or applicants	• Capital costs of water-measuring devices • Ongoing operating costs, including calibration and verification	• Enhanced management and systems performance monitoring (e.g. identifying leakages in system, assessing pump and well performance) • Improved farm planning • Ease of compliance monitoring • Consent holder and catchment benefit during water shortages, potentially increasing security of supply • Reduced transaction costs in consent applications • Improved ability to illustrate reasonable use • Ability to report water inputs – while not yet a 'need to know' in New Zealand's markets for agricultural products, it is a 'nice to know'
Regional councils and/or the wider regional community	• Costs of reviewing consents and administering the NES • Costs of enforcing the standard, and reporting at national level	• Improved water management and allocation efficiency • Improved compliance monitoring and enforcement • More accurate determination of natural flows • Better determination of minimum environmental flows and the minimisation of breaches • Enhanced planning for future economic growth, understanding actual usage and how it might change over time • Improved confidence in resource management • Improved confidence in compliance • Improved confidence in the setting of and compliance with environmental flows
Central government	• Costs of implementing and monitoring the NES and support • Implementation costs through the technical assistance programme	• Ease and effectiveness of national reporting on actual water take • Assists comparative analysis of actual water take between regions, and sectors

3.2 Quantification of costs

3.2.1 Capital and ongoing maintenance/calibration costs

A key component of the analysis is the quantification of the capital, installation, data-logging/transfer and maintenance costs associated with water measuring devices. The capital cost of measuring devices varies widely according to type (mechanical, ultrasonic, electromagnetic, indirect measurement), outlet type (pipe or channel), application (surface-water, groundwater, etc.) and size. Some measuring devices may not be suitable in some situations, and so the lowest-cost option may not always be the best solution. Installation costs also vary and are influenced by factors such as outlet type, choice of measuring device, access, and the extent to which existing head works or control structures require modification. Given that many regional councils already require that new water consents be measured, costs under the proposed NES are largely associated with retro-fitting measurement devices to existing structures.

The proposed NES does not specify that a flow-meter is required for measuring water take. A measurement method that can be independently certified as meeting the required accuracy standards will satisfy the terms of the proposed NES. Because it is not feasible to predict the extent to which alternative methods of measurement will be used, the cost analysis presented assumes that flow-meters are employed on pipe outlets and that fixed control structures are employed on channels to measure consented water take. We consider that flow-meters and fixed control structures will dominate the measurement of consented water take.

Tables 13 and 14 detail the capital and ongoing maintenance costs associated with measuring devices on pipe and channel outlets, respectively. Following are some of the key assumptions made.

- Although electronic data loggers are not a requirement of the NES, they are likely to provide the least-cost option in present-value terms for meeting the requirements of the proposed NES. If more manual methods of recording are used, requiring say 5 to 15 minutes per day at a cost of $30/hr, this would equate to $2.50 to $7.50 per day. If the average irrigation season is 150 days in length it is clear that a data logger costing $500 to $700 would quickly prove its worth.[5]
- Flow-meters have limited life spans. A 20-year life span has been assumed, with the capital cost repeated at 20-year intervals.
- In many situations the internal mechanism of mechanical flow-meters will not last 20 years. The costing recognises the replacement of the mechanical register at five-yearly intervals as a surrogate for calibration.

[5] Furthermore, although paper-based systems could meet the standard in terms of providing an audit trail, they may not provide for accurate and reliable data at the daily level. Horizons' experience with paper-based records suggests that periodic measurement is likely to be made and averaged over a number of days or weeks.

- The costs associated with establishing measuring devices on channel outlets are very site-specific. The costing assumes that the larger channel outlets are already subject to measurement, and therefore the costing is for modest channel takes.
- The installation costs assume measurement devices are installed by individuals who are able to provide satisfactory compliance certification to regional councils.

Table 13: Flow-meter costs for pipes

				Cost per measuring device			Cost per data-logger			Total installation costs			Five-yearly maintenance/calibration costs		
L/s	m^3/hr	Bore Ø mm	Takes /consent	Min.	Max.	Model input value	Min.	Max.	Model input value	Min.	Max.	Model input value	Min.	Max.	Model input value
0−5	18	50	1.0	$500	$2,800	**$1,650**	$500	$700	**$600**	$1,700	$3,600	**$2,650**	$200	$500	**$350**
>5−10	36	65	1.0	$800	$2,800	**$1,800**	$500	$700	**$600**	$2,200	$3,800	**$3,000**	$200	$500	**$350**
>10−20	72	80	1.0	$1,200	$2,800	**$2,000**	$500	$700	**$600**	$2,900	$4,100	**$3,500**	$200	$500	**$350**
>20−50	180	150	1.0	$1,300	$3,100	**$2,200**	$500	$700	**$600**	$3,500	$5,200	**$4,350**	$200	$500	**$350**
>50−100	360	150	1.0	$1,500	$3,100	**$2,300**	$500	$700	**$600**	$3,600	$5,200	**$4,400**	$200	$1,300	**$750**
>100−1000	3,600	200	1.3	$1,500	$3,800	**$2,650**	$500	$700	**$600**	$4,600	$7,700	**$6,150**	$200	$2,000	**$1,100**
> 1000		200	2.0	$2,000	$3,800	**$2,900**	$500	$700	**$600**	$7,100	$11,800	**$9,450**	$400	$4,000	**$2,200**

Primary sources: Arch Murray, Deeco Services Ltd; Roger Appleby, ABB Ltd; Mike Saunders, Prosol Limited; Bruce Kell, Ray Mayne, Hose and Fittings Ltd.

Notes:

- Physical installation costs range from $150 to $1,500 per device depending on type and size. Although not described individually, this cost is included in the 'Total installation costs' given in Table 13.
- It is assumed that a proportion of consents with a take rate of over 100 L/s have more than one take point and therefore require more than one measuring device.
- Five-yearly maintenance and calibration costs are based on in-field diagnostic calibration of electromagnetic flow-meters, laboratory calibration of ultrasonic flow-meters or the replacement of the full mechanical register in mechanical flow-meters. The replacement of the full mechanical register recognises the fact that the internal mechanism of mechanical flow-meters has a limited life span in most situations. The replacement of the mechanical register eliminates the need for five-yearly calibration.

Table 14: Measurement device costs for channels

L/s	m^3/hr	Control structure	Installation	Measuring device	Data-logger	Cost per unit installed	Three-monthly maintenance	Annual calibration
50−100	360	$2,500	$1,500	$1,500	$600	$6,100	$300	$500
>100−1000	3600	$2,500	$1,500	$1,500	$600	$6,100	$300	$500
>1000		$5,000	$2,000	$1,500	$600	$9,100	$300	$500

Primary Source: Dr Blair Miller, Scott Technical Instruments Limited.

3.2.2 Annual costs associated with reporting and compliance monitoring

The proposed NES requires the continuous volumetric measurement of water, recorded at least daily. It is also proposed that actual water take data be provided to regional councils by consent holders at least annually. Typically a variety of methods are employed by regional councils to collect consented water take data from measuring devices, including physical recovery by compliance monitoring staff, internet, email, “txting”, paper-based records and telemetry.

The costings presented in Tables 13 and 14 include those associated with an electronic data logger, but this does not rule out the use of other means of recording water take. Expertise and cost are involved in downloading the data recorded and providing it to the regional council. Environment Canterbury (2007b) report physical data collection costs in a distance-dependent range of $78 to $231 per consent for their Timaru office. This cost relates strictly to travel, accommodation (if necessary) and the downloading of the water take data. It does not include any post-processing. ECan report that an independent contractor offers a physical data collection and reporting service at a cost of $230 per consent for sites within 100 km of Timaru.

Data downloading could be performed by the individual consent holder/abstractor with the necessary tools, and could then conceivably be forwarded by email to the regional council. This may provide for a lower-cost option, but the extent to which this would occur is uncertain. Our determination of the annual cost of data download is therefore based on the service being provided by a third party, as follows:

Annual cost of data download

- Download and provision to council − $150 per device and $25 per additional device.
- Data processing and compliance reporting − $25 per consent.

The cost of downloading and subsequent processing is broadly based on the staffing levels given for this option in ECan’s 2007 business plan.Under the terms of the proposed NES, these costs will fall to the consent holder.

It is likely that councils will develop more cost-effective measures to capture water take data on a more frequent basis than that proposed by the NES. Under the NES, actual water take must be recorded daily and reported annually. Some councils require less frequent recording of take but more frequent reporting; others require real-time information. Telemetered methods or web-based initiatives, for example, may offer a means of doing this but involve significant capital expenditure. Although such methods are not recognised in the analysis presented, more refined implementation approaches may result in significantly reduced costs of data capture.

Clearly the storage and retrieval of a large amount of data requires database systems. Most councils possess database tools to support their hydrological resource management, and many already record water take data (to a greater or lesser extent). Many of the regional councils’ existing databases should be able to handle the increased levels of data storage required over time under the status quo, and initially under the proposed NES, but these systems would need to be enhanced sooner under the NES. No specific allowance has been made for this initiative beyond the implementation package proposed by the Ministry for the Environment, which will address this issue (see section 3.2.4).

Several regional councils have raised the prospect that the proposed NES will result in increased compliance monitoring costs. The costs established here include compliance with the NES. Section 35 of the RMA imposes a duty on regional councils to monitor compliance with consent conditions. The NES will effectively enhance or replace their compliance regime for take consents, and the costs associated with its implementation have already been fully costed in this analysis. We consider it unlikely that additional costs of compliance will be incurred over and above those already outlined.

3.2.3 Consent review costs

The gazetting of the proposed NES will require regional councils to initiate consent reviews. Under this process consent holders can request a full hearing. The cost of the review process will fall to the regional councils.

In the Auckland region, the implementation of the NES will require minor changes to the consent conditions, relating primarily to the frequency with which a consent holder must record water take. At present these consents require a weekly reading by the consent holder, whereas under the proposed NES daily reading will be required. Auckland Regional Council (ARC) estimate that the total cost of the consent review process is likely to be in the order of $14,500 for some 800 consents ($18.00/consent), which includes the development of educational material. The ARC believes that requests for full hearings are unlikely because the process will be able to be managed to avoid such events.[6]

ECan estimate that if the consent review process can be managed administratively (i.e. as a "deemed consent" process) it would require two full-time equivalent (FTE) staff working for four to six months to administer changes to some 6,000 consented water takes. If it is assumed that one FTE is required for a year at an organisational cost of $80,000/annum, this would equate to a staff cost of approximately $13/consent. If a full review process, including possible hearings, were required ECan estimate the cost would be at least double that of a simple administrative process. This does not include the actual cost of any hearing.[7]

Although consent holders can seek a full hearing under the review process, the likelihood of successfully challenging the proposed NES is considered to be low. The extent to which hearings may be requested is unknown, but given the low probability of success it can be anticipated that the number of requests for hearings will be restricted. Hearings can be expensive ($15,000 to $20,000 per hearing[6]), the cost of which will fall to regional councils. The cost of hearings under the consent review process therefore represents a risk to councils.

We estimate that the initial notification (year 0) cost of the consent review process will be about $25 per consent, and that further costs ($5 per annum per consent) will be incurred over the following five years to support the review process.

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6 Pers communication, Alastair Smaill, Auckland Regional Council, July 2007

7 Personal communication, Mike Freeman, Director of Regulation, Environment Canterbury, July 2007

Estimated consent review costs
• Initial consent review notification (year 0) −$25 per consent.
• Subsequent support (years 1 to 5) − $5 per consent per annum.

Note that these consent review costs only apply to the "with NES" scenario (see box above), with the exception of ECan. Under the status quo, the implementation of ECan's NRRP is recognised by including these review costs. The process of installing water-measuring devices under this plan will require consent review, the cost of which will fall to the regional council.

3.2.4 Central government costs

Central government costs are confined to those associated with gazetting the regulation, its implementation, and support and monitoring initiatives. Costs associated with gazetting the regulation are likely to be relatively minor and have not been able to be quantified. The Ministry for the Environment estimates that an implementation package of $300,000 per annum for five years will be required to support the introduction and implementation of the proposed NES. They also suggest that the costs of this package will be shared by central and local government. The proposed funding package will target education, communication, industry accreditation, database development, and a verification project.

Key informant interviews and submissions have consistently raised the issue of the certification of both measuring devices and technical installation staff. The availability of suitably qualified and competent technical service providers is raised as a key bottleneck in terms of meeting both the accuracy requirement and the implementation timeframe proposed by the NES. The New Zealand Water and Wastes Association (NZWWA) estimate that the costs of developing and running a series of educational seminars for industry professionals and installers is $250,000. The seminar series would be run over 12 months and allow for two seminars per council.

Further concerns have been voiced in relation to the possibility of inferior flow-meters entering the market. The NZWWA is aware that this is already occurring, and to prevent this they believe that adherence to some internationally recognised calibration/testing standard would be desirable. Possible standards include AS 3778 and ISO 4064.[8]

The implementation costs proposed by the Ministry would therefore be as follows, assuming a 50:50 split between central government and regional councils.

Implementation package costs
• Costs to central government − $150,000 per annum for five years.
• Costs to regional councils − $150,000 per annum for five years.

[8] Peter Whitehouse, Manager Advocacy & Learning, NZWWA, personal communication, July 2007

3.3 Potential benefits

Water is allocated as a flow rate and as a volume that can potentially be taken. Regional ability to monitor how much water is actually taken varies. As a result, many councils do not have a good understanding of the pressures on their rivers and aquifers to which observed changes in flows or levels can be related. The resulting uncertainty about the relationship between cause and effect is a significant impediment to robust water management decision-making and to the establishment of transparent and efficient allocation processes (Aqualinc, 2007).

The recognition that there are benefits associated with measuring consented water take is almost universal among stakeholders. The common thread is the potential for improved resource understanding and enhanced management of the resource at the catchment, in-stream and individual-user level. Approaches to implementing the knowledge gained from measuring consented water take are critical to deriving these benefits. The following looks at both the qualitative and quantitative benefits from installing water-measuring devices and the measurement of consented water take.

3.3.1 Improved compliance monitoring

Compliance monitoring and enforcement are important facets of resource management, helping to ensure equity and confidence in management regimes. Equity issues are as important to abstractors as they are to in-stream value stakeholders, and concerns relating to water resource management and compliance with consent conditions have been raised by a number of submitters to the proposed NES.[9,10]

In the absence of installed water-measuring devices, compliance monitoring of the consented take rate and/or volume may be based on intermittent measurement (ranging from annually to not at all) of rate and the recording of pump hours or power consumption, estimates of irrigated area and crop requirements. Although the Environment Court[11] considered that the use of records of power consumption might be suitable for ascertaining compliance with consent conditions, it is clear that this method can be imprecise and is limited to abstractions that employ electric motors.

The measurement of take rate combined with the recording of pump hours or power consumption can provide a coarse indication of usage, but neither method is an accurate measurement of actual water take. Field studies in South Africa report errors of up to 79 percent for pump hour methods, and errors of between ± 25 to 50 percent for kilowatt hour methods (van der Stoep et al., 2005). Enforcing consent conditions based on such measurement would be difficult, and the seriousness of the errors involved would make challenges to attempted enforcement inevitable for anything other than blatant non-compliance, such as that occurring during times of restriction.

Comprehensive, reliable and transparent compliance monitoring and reporting can provide for more equitable and efficient allocation of the resource during water shortages and

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[9] The Royal Forest and Bird Protection Society of New Zealand Inc., submission on proposed NES.
[10] R.D. Fenwick, Waimate, submission on proposed NES.
[11] Environment Court, Decision No. C108/205 Lynton Dairy Limited *v.* Canterbury Regional Council, 2005.

reduce transaction costs associated with consent applications. This is shown by Horizons Regional Council's compliance monitoring system of consented water takes. Real-time data are superimposed on consented take rates/volumes for individual consents and catchments and displayed on the internet. The system is largely self-policing, with interested parties able to observe compliance. The transparent nature of the compliance monitoring regime gives parties confidence that allocation regimes are being complied with, and this can lead to reduced transaction costs during consent application processes. Peter Taylor, of Fish and Game Wellington Region, reports that their confidence in the management of the resource by Horizons and confidence in compliance with consent conditions has allowed his organisation to be less involved in consent applications and able to support less conservative assumptions in relation to the setting of environmental flows.[12]

Successful compliance monitoring regimes combine a number of tools and implementation approaches, and water measuring devices are an essential component of these. Improved confidence in water resource management through the measurement of consented water take would occur over time under the status quo, but more immediately under the proposed NES. The value of improved public confidence is likely to be manifested as reduced transaction costs in resource decision-making. The NES does not require the monitoring of take rate, and in some situations this may limit the extent to which it results in improved compliance monitoring. Nevertheless, the NES should assist compliance monitoring.

3.3.2 Environmental flows

The determination of environmental flows is often a contested process, but some understanding of natural flow is a necessary part of determining environmental flows. Where water is being abstracted there is often a need to understand actual take in order to accurately determine "naturalised flow". In the absence of actual take data, assumptions regarding take are made or consented allocation is simply used as a proxy for actual take.[13]

Under the NES it is proposed that all consented water takes be measured, which means that actual take − and consequently naturalised flow − can be determined with greater accuracy than under the status quo. Although the uptake of water-measuring devices would increase over time under the status quo, it is unlikely to facilitate the comprehensive measurement of consented takes. For one thing, smaller takes are likely to be ignored in catchments other than those that are under significant stress from abstractors.

Under the proposed NES, more complete information on the volumes and rates taken in surface-water systems will:

- allow for a more accurate determination of naturalised flow and help to determine environmental flow regimes
- help to establish the influence of abstractions, if any, on the incidence and duration of breaches to these regimes
- assist water allocation committees (user groups) to more effectively manage the rationing of takes during times of low flow and to prevent environmental flow regimes from being breached through abstractive water take.

[12] Peter Taylor, Senior Fish and Game Officer, Fish and Game Wellington Region, personal communication, June 2007.
[13] John Bright, Aqualinc Research Limited. July 2007

Knowledge of actual take is particularly important during times of low flow, allowing for a more efficient allocation of the water resource to meet both in-stream values and the needs of abstractors. Aqualinc maintain that the protection of in-stream values could be enhanced by the "integration of water use records in consent processes to provide estimates of actual demand in the assessment of cumulative demand" (Aqualinc, 2004a). Their report recommends that takes greater than 10 L/s in Waikato be the subject of "logging", and that consent processes include the review of actual water taken.

In groundwater systems, complete information on take will allow for aquifer responses to be compared to actual extraction rates and provide opportunities for more accurate predictive modelling.

The case study (Box 1) illustrates the difficulties of attempting to set environmental flows in a contested situation in the absence of knowledge of actual water take.

Studies of non-market values (recreation use values, option values and existence values) suggest that New Zealand residents place a high value on the protection of the natural environment. Although it is not proposed that the values reported by these studies be included in the cost–benefit analysis, they are nevertheless useful to understanding the order of magnitude of likely benefits from improved water management and the protection of non-market values.

Sharp and Kerr (2005) provide a useful summary of New Zealand studies of non-market values, which indicates the potential magnitude of existence values associated with freshwater resources. The highest value reported per household ($203 per year) was produced by a local study, which looked at the values associated with reduced groundwater extraction on the Waimea Plains in Nelson (White et al., 2001 cited in Sharp and Kerr, 2005). This figure was nearly matched ($197 per household per year, Net Present Value, NPV = $2 billion) by the national study of values associated with proposed Kawarau River hydroelectricity developments (Kerr, 1985 cited in Sharp and Kerr, 2005). A study of the Ashburton River estimated preservation values both for Ashburton ($118 per household per year) and for the rest of Canterbury ($70 per household per year). Sharp and Kerr (2005) maintain that "the smaller regional values support the hypothesis that existence values decline with distance. Aggregating that regional figure over all Canterbury households indicates (largely non-use) NPV benefits from preservation of Ashburton River flows in excess of $70 million.

They also report that the:

> *... NPV of flow protection on the Waimakariri River for Canterbury households is in the order of $60 million. Existence values are generally confounded with use values. Changes in river attributes such as flow, pollution levels and even impoundment, can affect the amenity gained from activities such as boating, fishing, picnicking and walking. Amenity users may have higher existence values than others because of their familiarity with and affinity for the amenity.*

Box 1: Case Study – The impact of Waihao Catchment environmental flow decisions on irrigators

The Waihao River runs for around 95 km from its headwaters in the Hunters Hills., South Canterbury The catchment area of the Waihao River is estimated to be 580 km^2. The main flow recorder site on the Waihao is at McCulloughs Bridge, just below the junction of the north and south branches of the river. The mean flow is estimated at 3,585 L/s. The current minimum flow for irrigation abstraction is set at 250 L/s, and all takes are limited to 50 percent of allowable take at 600 L/s.

Of the 11 connected irrigation consents on the river:

- two were not being used, and a further consent that had not been used was proposing to instal an irrigation system in the coming year
- anecdotal reports were received that one consent had a system installed that was too large for its consented flow rates
- a number of consents had not been used in the past, but had recently been utilised through acquisition or leasing of land by other farmers in the area
- a number of consents were relatively recent.

Long-standing consent holders reported take patterns which varied according to season and the economic climate. The relationship between pumping costs and sheep/beef returns[14] is an important determinant in the use of take consents. In addition, farmers in the area reported convening informal water users group in times of restriction. As a result, takes could continue at a restricted volume while ensuring the required minimum flow was maintained.

Environment Canterbury wishes to set minimum flows for the river to account for environmental, landscape, recreational and cultural values. In doing so they have undertaken a number of studies of the values in the river system, and commissioned a report on the economic impacts of raising the minimum flows for irrigation abstraction to 380 L/s. The key hydrological data available to estimate the economic impacts of changing the minimum flow are the residual flows in the river at McCulloughs Bridge. While three of the consents for take were below the recording site, the remainder were above the site and therefore affected the flow at the recorder site. With 240 L/s of consented allocation above the recording site, at or near minimum flows the takes are close to an additional 50 percent of water in the river.[15]

No data on takes were available, and because the profile of abstraction had changed so significantly over the 20-year record there was no reliable way of estimating the takes to reconstruct the naturalised flows. As a result, the estimates of reliability under different minimum flow regimes are likely to overestimate the impact of changes to the minimum flows on the irrigators. Notably, the reliability estimates from ECan show lengthy cut-backs under existing minimum flow conditions, while irrigators in the catchment do not recall cut-back events of more than two weeks at a time. This has made accurate assessment of the likely impacts of different minimum flow regimes very difficult, and ultimately leaves both the decision-makers and the affected parties uncertain as to the outcomes under the management regime chosen.

[14] The existing reliability is problematic for dairy operations, although one operation is presently irrigating from the river, augmented by storage and groundwater.

[15] Because the takes are already restricted to 50% below 600 L/s.

Sharp and Kerr (2005) conclude that "existing studies indicate that New Zealand residents can place high value on protection of the natural environment", and "that changes in existence values typically arise because of impacts on the structure and functioning of the natural environment". On this basis it is reasonable to assume that improvements in the management of water resources and environmental flows will be accorded a high value by New Zealand residents.

3.3.3 Potential allocative efficiency gains

In the absence of actual take data, the determination of the reasonable needs of consented water users is based on relatively simple models. The determination of the degree to which a resource is allocated is often based on these same models. However, actual take is often significantly different from consented allocation. In irrigation-type allocations this difference arises principally as a result of rainfall varying from year to year, but other factors such as crop maturity and types, stage of farm development and other economic factors also contribute to this difference. In industrial applications differences may arise simply because the industrial activity does not operate for the 365 days per annum assumed.

Aqualinc's (2006b) report of actual take versus consented allocation for irrigation purposes shows consistent trends across the regions studied:

> *They show similar trends in terms of variability in use, low use on the irrigation season margins (early and late season) and considerable variations between seasons. This is to be expected as allocations are generally issued as a fixed peak take rate intended to provide a high level of supply reliability while demand varies according to climate, crop type and growth stage. On a catchment or groundwater zone, maximum use is up to 80 percent of allocation during periods or seasons of high demand. However, it is on average generally around 50–60 percent of allocation.*

Aqualinc (2006b) report that in the Manawatu−Wanganui region:

> *… water use for municipal water supplies to several towns was typically up to a maximum of 60 percent of daily allocations (Marton, Halcombe and Ohakea). However, water use for rural water takes was more variable both in daily use and frequency of use, ranging from less than 20 percent to more than 100 percent.*

In the Waikato region a lack of knowledge regarding actual take is reported as reducing allocative efficiency:

> *Water use [is] lower than consented take rates and volume. Comparison of consents and water use records indicated that actual use is approximately 80% of the consented take (based on records of supply networks). This effectively reduced allocation efficiency by 10%.* (Aqualinc, 2004a)

Because the models used for estimating take are reasonably coarse, data on actual take create significant potential for allocative efficiency gains.

These gains arise through:

- identification of un-utilised allocation
- refinement of estimates of the degree of effective catchment allocation
- improved resource understanding, allowing for less conservatism in the setting of allocated volume at the catchment level.

Each of these is discussed below.

1. Identification of un-utilised allocation

Actual water take by consent holders is typically less than their consented allowances. Identifying actual take can therefore allow for water to be made available within the consented allocation. It is important to note that water made available in this way can be reallocated through a number of mechanisms: internally by the consent holder, through transfer to other parties, or clawed back and reallocated by the regional councils. The discussion below identifies cases in ground- and surface-water systems where measurement has identified and made available unused water within consented allocations.

Groundwater systems

It has been the experience of both ARC and Horizons that the measurement of actual water take has allowed un-utilised allocation to be identified and clawed back for reallocation to other uses.[16,17] Unfortunately, the degree to which this has occurred and the end use to which the un-utilised volume has been put has not been documented. In Horizons' case the application of volumetric charges under section 36 of the RMA, whereby consent holders are charged based on the volume allocated, has assisted the claw back.[18]

In the late 1980s ARC implemented the measurement of consented water take. As part of this process, consents were reviewed and conditions specifying annual volume allocations were imposed. Initial annual allocations for the Kaawa Aquifer were based on relatively simple calculations for maximum daily take rates and the number of days this take rate would be utilised. Subsequent actual consented take data from measurement allowed these initial allocations to be refined and reduced over time. Further refinement also included the development of soil and crop water utilisation models. In the Kumeu district, refinement of allocations based on actual water take for irrigation purposes showed the use factor initially developed for seasonal irrigation in the Kaawa Aquifer could be reduced, essentially freeing up the previously un-utilised component of the allocation. Actual consented water take data associated with all-year-round users allowed more refined allocations to be set for individual users, recognising that these uses may not operate for the 365 days at the peak daily allocation, as assumed in the initial allocations.[19]

Surface-water systems

Allocative efficiency gains can be made in surface-water systems when real-time data are available to monitor take. However, this requires telemetered measurement. Although the NES does not require telemetering of surface-water takes, the potential allocative efficiency

16 Alastair Smaill, Auckland Regional Council, personal communication, June 2007

17 Jon Roygard, Horizons, personal communication, June 2007.

18 Under volumetric pricing there is some motivation for consent holders to give up allocation that is un-utilised and does not threaten the perceived need for reliability. Behavioural change in response to volumetric pricing through water metering is well documented in the international literature.

19 Andrew Millar, Water Resources Officer, Auckland Regional Council, personal communication, July 2007.

gains are provided by the presence of a water-measuring device. An example of such gains is given in Aqualinc's (2004b) report on the Waihou catchment for Environment Waikato, whereby knowing what was being taken, and when, could allow for the:

> *... establishment of a secondary class of take consents (B share), for either under-utilized allocations (for example seasonal irrigation takes) and or allocations above current water availability criteria. The secondary take would be restricted at a higher flow rate threshold than current allocations (i.e. above Q_5), and therefore less reliable.*

A further example of this is Synlait's consent application on the Rakaia River, whereby they sought to identify unallocated water that can only be accessed when existing irrigators are not taking their maximum consented rate. Synlait report that their proposal would irrigate 6,000 ha.[20]

Further benefits that result from such an approach include:

- reductions in energy use − pumping surface-water is significantly less energy intensive than pumping groundwater
- delaying the need for infrastructural development.

2. Refining the extent of allocation

In groundwater catchments where allocations are set using flow rates rather than volumetric allocations, the assumptions about the amount of water taken will determine whether the catchment is considered fully allocated. The following case study (Box 2) illustrates how better information on consented water take may lead to improved allocative efficiency, via refined estimates of the extent to which a resource is actually allocated.

The consent sought by Lynton Dairy Ltd was granted by the Court, albeit with conditions on annual volume and duration. Accurate knowledge of actual water take would have greatly reduced the transaction costs associated with this hearing. It is evident from the Environment Court's decision that they considered the measurement of actual water take to be a vital component of any water allocation policy.

[20] Andrew Barton, Environmental Manager, Synlait, personal communication, June 2007.

Box 2: Case Study – Lynton Dairy Ltd *v.* Canterbury Regional Council

Actual take is an issue that particularly vexed the Environment Court when considering Lynton Dairy Ltd *v*. Environment Canterbury. The Court considered knowledge of actual take to be especially important in determining effective allocation, as many groundwater consents in the region do not possess annual volume allocations and have simply been set maximum instantaneous take rates.

Lynton Dairy Ltd sought consent to take 516 L/s from a deep aquifer at Te Pirita in Central Canterbury near the Rakaia River with the intention of irrigating some 1,000 ha of dairy pasture. The application was refused by the regional council, "largely based on the potential cumulative effects on lowland waterways and users some 40 kilometres away from the farm".[21]

A central tenet of the case was whether or not the resource was fully allocated. While there appeared to be little disagreement between parties over the total volume available for allocation, there was considerable disagreement as to the extent to which this volume had been effectively allocated. ECan's determination of the degree of effective allocation was based on the assumption that 60 percent of the maximum consented instantaneous take is utilised continuously for 150 days. The Court, however, determined that this overestimated abstraction even in a dry year, as the maximum usage recorded was 52 percent. It was determined that an appropriately conservative estimate of effective allocation is 50 percent of the volume, calculated by assuming maximum consented instantaneous take is utilised continuously for an irrigation season of 150 days.

The Court considered that it was unfortunate that there was such disparity in estimates regarding effective allocation and that:

[56] It is important to estimate irrigation usage for the following reasons:

(a) it constitutes more than 80% of the water consumption within the region and even more of this within the Rakaia Selwyn zone;
(b) that without being able to correctly ascertain the amount of water utilised, it is difficult to ascertain the extent of the resource currently used or available for use;
(c) knowing the mount of water used is vital for calculating the amount of recharge that will be occurring from irrigation back to groundwater.

In short, actual water usage is a vital component of any allocation policy as anticipated in the PNRRP:5.

In addition:
Monitoring of Abstractions

[187] There was contradictory evidence as to the annual abstraction (effective allocation) in the Rakaia Selwyn Groundwater Allocation Zone. The Regional Council advanced figures in excees of 200 Mm^3/yr while Mr Callander suggested a figure in the low 100's of Mm^3/yr. Such uncertainty underlying the allocation of a resource is at best unfortunate. Monitoring conditions are a suitable response. Such a condition might read:

The consent holder shall monitor and record the abstraction rate, monthly volumes and the seasonal volume extracted either by monitoring the discharge directly or by using records of power consumption by the pump. The results of monitoring shall be available for inspection by a Regional Council officer at any reasonable time.

[188] This condition should be imposed on all new and renewal consents. The regional Council may also wish to consider imposing this requirement ion existing consents which have an appropriate Section 128 condition.

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[21] Environment Court, Decision No. C108/205 Lynton Dairy Limited *v*. Canterbury Regional Council., 2005.

[23] Liz Lambert, Hawkes' Bay Regional Council, personal communication, June 2007.

3. Improved resource understanding

A further set of allocative efficiency gains may also be possible at the catchment level determination of total allocatable volumes. Regional water managers report that in the absence of information, conservative assumptions are employed in setting allocatable volume.[23,24] The potential for allocative gains through better resource understanding, and therefore reduced conservatism, is evidenced in the in-house reports prepared as part of ECan's Proposed Natural Resources Regional Plan (PNRRP).

> *The following discussion refers to first order, second order and third order approaches to setting allocation limits. The first order reflects a lower level of understanding about recharge sources, whereas with the third order approach, the groundwater system and sources of recharge are well understood. Therefore there is a lower level of certainty about the amount of groundwater that can be allocated with a first order approach. It is necessarily precautionary to reduce the risk of adverse environmental effects resulting from high allocation. With greater knowledge the second and third order approaches can be applied and in general are likely to result in an increase in the amount of groundwater available.* (Environment Canterbury, 2004)

Knowledge of actual water take is an important component of second- and, in particular, third-order approaches to modelling groundwater systems and setting allocation limits. Third-order approaches should allow modelling to break free of relatively simplistic and often conservative assumptions, allowing for the effects of abstraction on the environment to be more accurately determined.[25] Third-order models are demanding of data. Actual water take is just one of the required inputs and as such is not the sole limiting factor in the development and use of such models.

Summary

In the absence of knowledge about the actual take, the conclusion is often drawn that a resource is fully allocated before it actually is. The refinement of allocation made possible through measurement − implementation mechanisms aside − has the potential to free up water in catchments that are presently considered to be highly allocated. Aqualinc estimate that knowledge of actual water take has the potential to free up 5 to 10 percent of allocated volume in what are considered to be highly allocated regions. They consider that achieving an allocative efficiency gain of 10 percent would take 15 to 20 years and would require the development of appropriate political processes along with more sophisticated models and management of the resource. A five-percent allocative efficiency gain is, however, more readily achievable.[25]

Quantifying potential allocative efficiency gains

The quantification of the benefit arising from allocative efficiency gains has been made for a scenario in which an increased level of consumptive take by irrigators is enabled. Estimates made by MAF (2004) of the value of irrigation to New Zealand form the basis

[24] Mike Freeman, Director of Regulation, Environment Canterbury, personal communication, June 2007.
[25] John Bright, Aqualinc Research Limited, personal communication, July 2007

for evaluating the magnitude of gains associated with improved allocative efficiency.[26] These estimates of value to the economy (as Gross Domestic Product, GDP) have been translated into an estimate of farm gate benefit[27] and applied to the likely additional water released as a result of efficiency gains. This water is likely to be made available as a result of:

- identifying water that is not being used by consent holders − this could be made available for further use by consent holders using it internally (e.g. by extending their irrigated area, by transferring the unused portion of water to another party, or by the consenting authority using claw-back provisions to take the water off the consent holder and reallocating it to other parties)
- improvement in understanding of the extent of allocation and the water resource in a catchment (particularly groundwater), leading to water being available within the allocation limit and less conservatism in setting the allocation limit.

Gains from allocative efficiency will only occur in areas where catchments are at or near full allocation. Using data from the New Zealand Business Council for Sustainable Development report (Aqualinc, 2007) which identified catchments that are approaching full allocation on a regional basis, the number of catchments in which significant gains in allocative efficiency may occur has been estimated. Regions where such benefits are possible include Canterbury and Otago, and to a lesser extent Tasman, Marlborough and Waikato.[28]

The volume of water likely to be released for consumption is based on the 5 percent estimated by Aqualinc.[29] If 5 percent of the water in constrained catchments becomes available for reallocation, the value of water-based benefit gain is estimated at $48 million per annum (Table 15). To put this in context, 78 percent of water consents are used for irrigation (Aqualinc, 2006b), with the value contribution of irrigation to farm-gate GDP (2003) estimated as $920 million (MAF, 2004).

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[26] MAF estimated the value as changes in GDP (Annex II, Table A1). These figures are the most reliable national representation, and because they average across a number of land uses are more suitable for the type of analysis undertaken here. However, the authors of that report note that their estimate of contribution to GDP from irrigation is likely to be conservative because it does not take into account the potential for downside fluctuations in output from dryland farms, nor the flow of benefits from irrigated farms to dryland farms. Furthermore, these are farm gate estimates of GDP, and do not consider flow-on impacts to the wider community. Nevertheless, they represent a useful large-scale reference for the value of irrigation in the New Zealand economy.

[27] In order to translate these estimates of GDP into benefit, they have been adjusted by subtracting labour costs (from MAF Farm Monitoring Report data for the 2002/03 season) and capital costs for transition (from Harris Consulting, *Regional Economic Analysis: Uses of Water in the Waitaki Catchment*, report prepared for Ministry for the Environment and the Waitaki Catchment Water Allocation Board, 2004) between different farming systems. Capital costs were converted into per annum costs using a rate of 8 percent per annum. The adjustments made are shown in Annex II, Tables A2 and A3.

[28] Allocative efficiency gains are only made where water is scarce. They do not occur where water is abundant, as water users can simply apply and gain consent. Annex III presents a case study of the West Coast Regional Council, a region with abundant water resources.

[29] John Bright, Aqaulinc, personal communication, July 2007.

Table 15: Estimate of net benefit from a 5 percent increase in allocatable volume for water taken for irrigation

Region	Available irrigable area ha	Potential increase in irrigated area ha	Benefit $/ha/annum of irrigation in region	Benefit[30] of increased area $million/annum
Waikato	51,168	397	$3,814	$1.5
Canterbury	352,994	29,115	$985	$28.7
Marlborough	9,410	1,647	$4,166	$6.9
Otago	158,725	6,357	$1,191	$7.6
Tasman	11,729	822	$4,320	$3.6
Total	**584,026**	**38,338**	**$14,476**	**$48.3**

Such gains cannot be attributed entirely to the measurement of consented water take under the proposed NES, however. For one thing, the implementation approach adopted will be critical. There are transaction and other costs that will need to be offset against these gains, the extent of which will depend on how the gains are achieved. If the reallocation occurred internally to the farming system, then the transaction costs are relatively minor. Transaction costs increase with reallocation through external transfer and claw-back by regional councils. In the case of telemetry, this has an infrastructure cost over and above the established costs of the proposed NES.

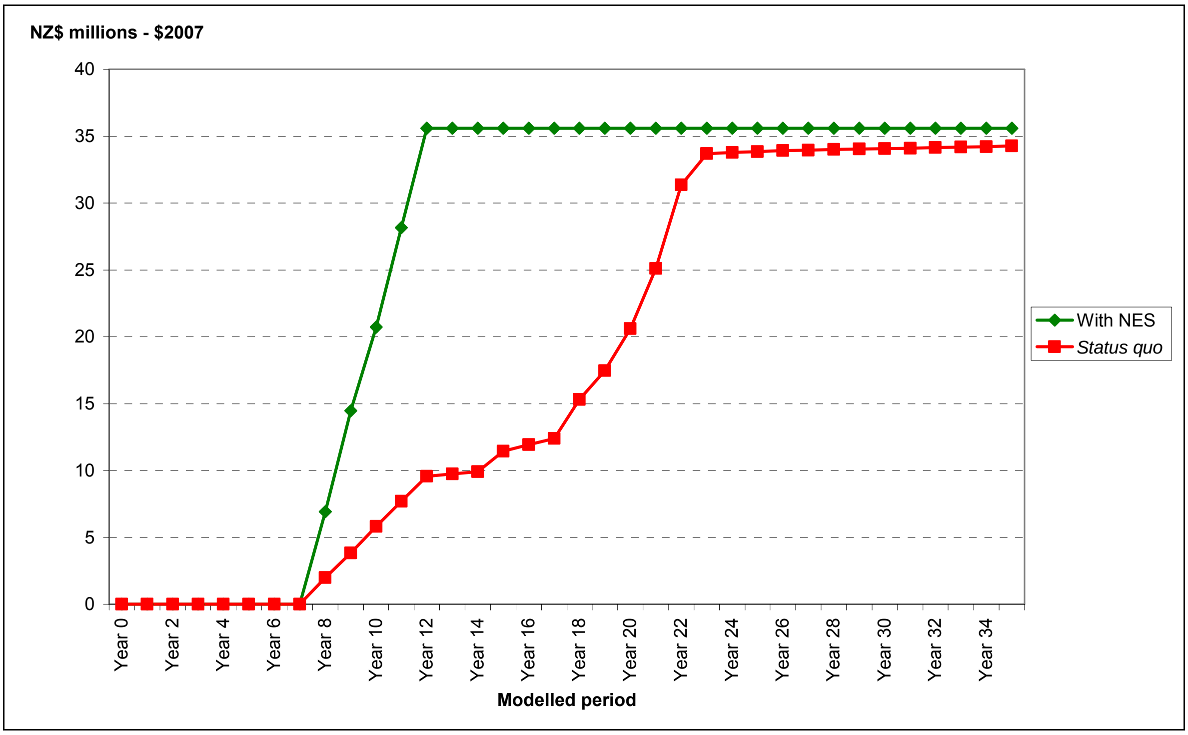
There will also be constraints to these benefits being achieved. The availability of labour, capital and other resources is likely to be constrained if significant irrigation development occurs in a short period of time. There is also the possibility of environmental constraints on the ability to further intensify land use in some locations due to limits on the emission of nitrates, microbes and other contaminants. For these reasons, the estimate presented should be treated as indicative only, although it does provide an order of magnitude estimate of the likely benefits.

In conjunction with these benefits there are costs, including environmental costs. Water that was previously available for environmental flows because it was unused by consent holders would be extracted and used. Even though this would occur within an allocation limit specified by the planning authority, it will have some impact on the water body. The downstream impacts of intensification that result from increased water take will also create costs to users and ecosystems, even if these are within environmental limits. These costs include emissions of nitrates, microbes, phosphorus and greenhouse gases.

The allocative efficiency benefit of the proposed NES results from benefits arising earlier than they would in the status quo. The financial benefits identified have been modelled as arising over five to ten years following the installation of measuring devices. The extent of the benefits has been limited to the proportion of unmeasured takes versus total takes, and has been restricted to takes of greater than 20 L/s. Figure 3 describes the timing of benefits as they arise under the status quo and the proposed NES.

[30] This is based on existing irrigated land use. It is likely that the benefit associated with future land uses under irrigation will be higher than the average of existing land uses.

Figure 3: Timing of financial benefits, assuming 5% increase in allocatable volume for consumption



Allocative efficiency gains need not be limited to irrigators. Other potential beneficiaries may include municipal water supplies and industrial users, or improved environmental flows. Under this latter scenario, councils will have determined that the value of water as environmental flows is equal to or greater than its value as consumptive use.

3.3.4 Technical efficiency gains

Although there is some indication that measurement of consented water take may improve the technical efficiency of use through enhanced management and behavioural change, these gains are likely to be smaller and more difficult to identify than allocative efficiency gains.

The Foundation for Arable Research (FAR) maintains that "water measurement at one point may help measure use of water for irrigation but it does not ensure the efficient use of water for irrigation. Thus water measurement may have very limited impact on efficient water use."[31] Despite this qualification, the measurement of actual water take is a necessary input to technical efficiency parameters such as ML/kg of yield, kW/ML, gross income/ML, etc.

Results from metered extraction trials in South Australia report benefits to irrigators from measuring water take at the point of extraction, allowing them to calculate efficiency factors and indices (Latcham et al., 2006). The authors state that "over 2,200 water meters have now been installed, costing licensees an estimated $7 million. However, many irrigators now claim it was money well spent as they have been able to identify costly inefficiencies coupled with the ability to make more informed decisions regarding their

[31] Foundation for Arable Research, Lincoln, New Zealand, submission on proposed NES.

water use." The Cooperative Extension Service of Kansas State University in the United States affirms that in most cases water-measuring devices will pay for themselves in "watering savings, optimum yields, and lowered energy costs" (Rogers and Black, 1992). Unfortunately, both publications are short on detail as to the magnitude of the benefits gained.

By measuring water take, abstractors are able to monitor the performance of pumps, intakes and wells. Any significant variation in flow rates may indicate that the pump, intake or well is no longer performing optimally. The ability to measure this before it becomes visually obvious can reduce pumping costs and avoid costly downtime. Dr Tony Davoren of Hydroservices Limited reports that in a typical irrigation season at least five of his 400 clients will suffer pump or well problems, resulting in costly losses in yield.[32] The monitoring of pump flow rates and volumes would allow for any decline in performance to be identified early and rectified outside of the growing season, avoiding costly crop yield losses. Dr Davoren estimates that the loss of two weeks' irrigation during a Canterbury growing season can result in the loss of 9−12 percent of potential yield (a loss of ≈ \$300–500/ha) for a producer of ryegrass seed, and 2,500−3,000 kg/ha of dry matter in a dairying situation − the equivalent of \$440−450/ha return in milk solids.

The $PV_{10\%}$ loss of revenue for Dr Davoren's clients is estimated at \$5,300.[33] The $PV_{10\%}$ cost of a water-measuring device, including ongoing costs over a 36-year period, is estimated at \$7,300. It is evident that, using these assumptions, the cost of the water-measuring device could to a large extent be offset by the benefit (avoidance of revenue loss) gained from the farming system. However, this benefit cannot be attributed entirely to the installation of a water-measuring device because there are other, perhaps more cost-effective, ways to monitor pump, well and/or intake performance. Such methods include periodic audit of irrigation systems and the installation of pressure gauges and/or an ammeter.

Behavioural change in response to the measurement of water take and in the absence of metered base charging has been reported in municipal and agricultural situations. The installation of urban water meters in Tauranga over the period 1999 to 2002 resulted in significant reductions in water take (Tauranga City, 2004). This was achieved in the absence of meter-based charging (which was introduced in 2002), but did include a significant education programme.[34]

When working on conservation measures in surface-water-based irrigation districts in the Lower Rio Grande Valley, Dr Guy Fipps found that water measurement in itself reduced water take by 10 percent. When measurement was combined with training farmers in appropriate on-farm irrigation management, water take was reduced by 20−40 percent (Fipps, 2000). Although these results were achieved in the absence of volume-based pricing, Dr Fipps reports that "to get a grower to improve their on-farm water management, there must be some sort of incentive, sometimes this is the cost of water or energy for

[32] Dr Tony Davoren, Hydroservices Limited, Christchurch, personal communication, June 2007.

[33] This assumes a probability of 0.0125 for the loss of two weeks' irrigation during the season, and a revenue loss of \$400/ha for an irrigated area of 100 ha.

[34] Allan Dale Domestic Water Advisor, City Waters, Tauranga City Council, personal communication, June 2007.

pumping, but may also be water allocation/supply restrictions, the promise of improved production, water shortages, etc."[35]

In the New Zealand context, both *The New Zealand Irrigation Manual* (Malvern Landcare Group, 2001) and the *Irrigation Code of Practice and Irrigation Design Systems* (Irrigation New Zealand, 2007) identify the potential for efficiency gains to be derived from measuring water use. Both publications identify savings in water use and energy use as potential benefits. Table 1Table 16 describes the level of energy saving required to offset the capital and ongoing costs associated with installing water-measuring devices on two Canterbury farm types. Importantly, it is a combination of tools (including soil moisture monitoring) that allows for any benefit to arise, and so the benefit cannot be entirely attributed to the installation of a device to measure actual water take. A similar result may also be gained from alternative measurement methods such as the use of rain gauges and/or the periodic audit of irrigation systems.

Table 16: Energy savings required to offset the cost of a flow-meter on two Canterbury farm types

Farm type	Pump capacity	Electricity cost[36] ($/annum)	Annualised cost of flow-meters ($/annum)	Energy-saving required to offset cost of flow-meter
Mid Canterbury irrigated crop	70 kW	$18,000	$700	4%
Central Canterbury large dairy farm	2 x 100 kW	$83,000	$1,600	2%

It is evident from the stakeholder interviews and the literature that there may be some benefit in consented water users monitoring their water take and use. This benefit may even, in some situations, significantly offset the capital and ongoing costs associated with the installation of a water-measuring device.

3.3.5 Accounting for water

Sustainable development has been defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".[37] The path to sustainable development requires readily available information about the links between the economy, the environment and society.

Natural resource accounts consist of stock and flow, measured in physical and monetary units. As such, they help provide a measure of New Zealand's total natural wealth and provide information that can improve resource management. They can also help determine whether natural resources are being utilised efficiently on a national basis and across sectors. They may also be used to assess the physical and monetary extent of environmental depletion and degradation.

[35] Dr Guy Fipps, Professor and Extension Ag. Engineer Director, The Irrigation Technology Center, personal communication, July 2007.
[36] Derived from the energy calculator prepared for MAF by Stuart Ford of the Agribusiness Group.
[37] Rio Declaration on Environment and Development, 1992.

Natural resource accounts can help researchers analyse the effects of environmental policy on the economy, and of economic policy on the environment. Environmental accounts can, for instance, be used to establish which industries are reducing their reliance on natural resources relative to their contribution to GDP, a concept known as "decoupling". This analysis can only be done if accurate data describing actual water take and use are available.

Statistics New Zealand reported in January 2006 that:

> *New Zealand is the only Organisation for Economic Co-operation and Development (OECD) nation that has not compiled a set of environmental accounts. Producing these accounts will, among other things, help New Zealand meet its commitments under various ratified international conventions.*[38]

The recently released *Water Physical Stock Account 1995−2005* by Statistics New Zealand (2007) highlights the paucity of data surrounding actual water take. The authors state that :

> *there is insufficient data for the current stock accounts to quantify the volumes of water abstracted for the following purposes:*
> - *irrigation*
> - *livestock use*
> - *private domestic use*
> - *private industrial use*
> - *geothermal electricity generation.*

Under the United Nations-endorsed System of Environmental-Economic Accounting for Water (SEEAW), physical information from industries and households on water abstraction, use and supply within the economy and returns in the environment are key inputs.[39] Measurement of actual water take is also a fundamental requirement of the Sustainable Water Programme of Action (SWPOA), led by the Ministry for the Environment. SWPOA is, among other things, concerned with improving efficiency of use, and efficiency cannot be determined without comprehensive and accurate measurement of actual take. Therefore, such measurement is an important condition for achieving and demonstrating improved efficiency at all levels (individual, industry, regional and national).

McIndoe et al. (1998) report that "six of the sixteen economic and environmental indicators of sustainable irrigation recommended in MAF Policy Technical Paper 00/03 have water use as one of their components." They go on to say that:

> *... to calculate these indicators, each day the total volume of water used on a farm for irrigation and the rate at which it is taken must be measured. This enables total seasonal volumes and depths of water applied to be calculated. Without flow measurements, the key indicators of sustainable irrigation cannot be determined.*

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[38] http://www.stats.govt.nz/analytical-reports/natural-resource-accounts/default.htm [Accessed 17 July 2007]
[39] http://www.perfilambiental.org.gt/seminario/presentaciones/Ilaria_Dimateo.pdf [Accessed 17 July 2007]

McIndoe et al. argue that the ideal place for measuring water for irrigation efficiency calculations is at the irrigator. They recognise, however, that there are challenges in doing so, and that measurement at the pump is an acceptable method where a single irrigation unit is involved.

Further benefits arising from knowledge of actual water take reported in the New Zealand context include an improved ability to make on-farm allocation decisions when working within a volumetric allocation, and the ability to demonstrate reasonable and efficient use to regional councils and to markets.[40] The ability to be able to demonstrate reasonable use during consent application/review proceedings can substantially reduce the associated transaction costs, and the need for producers to be able to demonstrate "sustainability" and the efficient and reasonable use of resources is a growing trend in international markets.[41]

The proposed NES will improve the ease and effectiveness with which actual water take can be reported. Under the status quo, comprehensive measurement of take is unlikely to be achieved within 15 to 20 years. The proposed NES will allow more complete physical water accounts to be compiled within five years of the regulation being gazetted. This will help the nation to meet its international obligations to report the status of its natural environment.

40 Bill Davey, Farmer, Rakaia, Canterbury, personal communication, June 2007.
41 Jon Manhire, AgriBusiness Group, Christchurch, personal communication, June 2007.

4 MODELLING THE STATUS QUO AND THE PROPOSED NES

The costs and benefits of the proposed NES will largely be associated with the differences in the extent to which measuring devices are required and the timeframe for consents to include a water-measurement device. For example, many regional councils already require that new consents be subject to measurement, and that measuring devices be installed upon the replacement of existing consents. The NES proposes that this occur within five years of gazetting.

The modelling of the timing of the uptake of measuring devices has been derived from the water allocation consent database prepared for the Ministry for the Environment by Aqualinc (2006a, 2006b, 2006c). This database describes all consented water takes in terms of take rate, annual allocation, outlet type, primary use, consent expiry date, etc. The database does not, however, describe whether or not an individual consent is the subject of measurement. This is achieved through analysis "of the number of consents without measuring devices and assumes that the current distribution of metered consents is similar to the distribution of take rates" (Aqualinc, 2006b). The consents database provided by the Ministry has allowed for the modelling of the uptake of water-measuring devices by region, take rate and consent expiry date.

4.1 Modelling the status quo

Many regional councils already require that new water consents be measured and that existing consents be measured upon replacement. Modelling of the status quo assumes that water-measuring devices will be installed upon consent replacement and, in the case of Canterbury, under consent review processes and the implementation of an operative Natural Resources Regional Plan. There will, however, be exemptions, generally associated with smaller take rates. The modelling of specific exemptions has created the need to make some assumptions regarding take rates that are likely to be exempted under the status quo. Table 17 details these assumptions.

The status quo results in some 10,300 water-measuring devices being installed over a 36-year period. This value includes those installed within the timeframe of the proposed NES, either voluntarily or under consent review processes and at consent replacement. Voluntary uptake of measuring devices includes the installation of measuring devices under consent review processes (outside of consent replacement) and is likely to result in a significant number of measuring devices being installed under the status quo but within the proposed timeframe of the NES. An example of this is the likelihood that some 600 consents in the Rakaia−Selwyn District, that are the subject of a consent review process, will be required to have measuring devices installed. We have assumed that 25 percent of existing unmeasured takes, over and above those required at consent replacement, would instal measurement devices within the proposed timeframe of the NES, which is consistent with the assumption made in the preliminary cost−benefit analysis (Ministry for the Environment, 2006). This assumption appears reasonable given current initiatives by various regional councils (ECan, Hawkes' Bay Regional Council, etc.).

Under the status quo, some 2,500 (13 percent) consented water takes will remain unmeasured at the end of the 36-year period. These primarily relate to take rates of less than 5 L/s. This figure also includes 432 consents associated with the West Coast Regional Council.

Table 17: Status quo model assumptions – uptake of measuring devices

Council	Assumed uptake of measuring devices
Northland	Measuring required upon consent replacement for take rates > 5 L/s.
Auckland	All consents currently measured.
Waikato	Measuring required upon consent replacement for all take rates.
Bay of Plenty	Measuring required upon consent replacement for take rates > 5 L/s.
Gisbourne	All consents currently measured.
Hawke's Bay	Measuring required upon consent replacement for take rates > 10 L/s.
Taranaki	Measuring required upon consent replacement for all take rates.
Manawatu-Wanganui	Measuring required upon consent replacement for take rates > 5 L/s.
Greater Wellington	Measuring required upon consent replacement for take rates > 20 L/s.
Tasman	Measuring required upon consent replacement for take rates > 5 L/s.
Marlborough	Measuring required upon consent replacement for all take rates.
Nelson	Measuring required upon consent replacement for all take rates.
West Coast	No measurement of consented water take.
Canterbury	Measuring required upon consent replacement for all take rates. Consent review requires meters in specific areas (e.g. Rakaia−Selwyn) and under an operative NRRP water-measuring devices will be installed universally on consented takes within 15 years.
Otago	Measuring required upon consent replacement for all take rates.
Southland	Measuring required upon consent replacement for take rates > 5 L/s.

4.2 Modelling the proposed NES

Under the proposed NES all consented water takes will be required to measure actual water take within five years of the regulation being gazetted. Because the NES specifies standards for measuring devices, it affects some consents that are currently measured as well as those that are not currently measured.

Consents that are currently measured

In modelling the uptake of water-measuring devices it needs to be recognised that a proportion of existing devices will not meet the standards of the proposed NES. Currently measured devices include those that have been installed:

- under an existing consent, where the consent conditions exceed those of the NES
- either voluntarily or under consent conditions that do not meet the NES.

Where existing installed measuring devices are subject to consent conditions that are equal to or better than those given in the proposed standard, it has been assumed that they will meet the requirements of the NES. It is likely that some will not, but this becomes a compliance issue associated with the council. That is, if they do not comply with their consent condition, they are also unlikely to comply with the NES, and therefore the proposed standard does not add any additional cost to that already imposed by consent conditions.

Water-measuring devices that have been voluntarily installed or installed under consent conditions less rigorous than the NES may not meet the conditions of the NES. Key reasons for non-compliance include:[42]

- an inability to meet the ± 5% accuracy standard due to wear and tear on mechanical meters
- the installation does not meet the manufacturer's specifications.

Mechanical meters installed more than four to five years ago are unlikely to meet the accuracy standard, due to wear and tear. These meters would require either complete replacement or replacement of the mechanical register. Mechanical meters are particularly vulnerable to wear and tear when used to monitor surface-water takes, or when water has high silt content, or where there are elevated levels of magnesium and iron. Instances where a meter installation fails to meet the manufacturers' specification are likely to be confined to those installed more than five years ago.

Little is known about the extent to which currently installed measuring devices meet the proposed standard. We have assumed that 20 percent of existing water-measuring devices would not meet the proposed standard and would require replacement. This is consistent with the assumption employed in the preliminary cost−benefit analysis reported by the Ministry for the Environment (2006). This assumption is tested via sensitivity analysis.

Unmeasured consents

The analysis assumes that all unmeasured consents have compliant water-measuring devices installed over a five-year period.

4.3 Summary

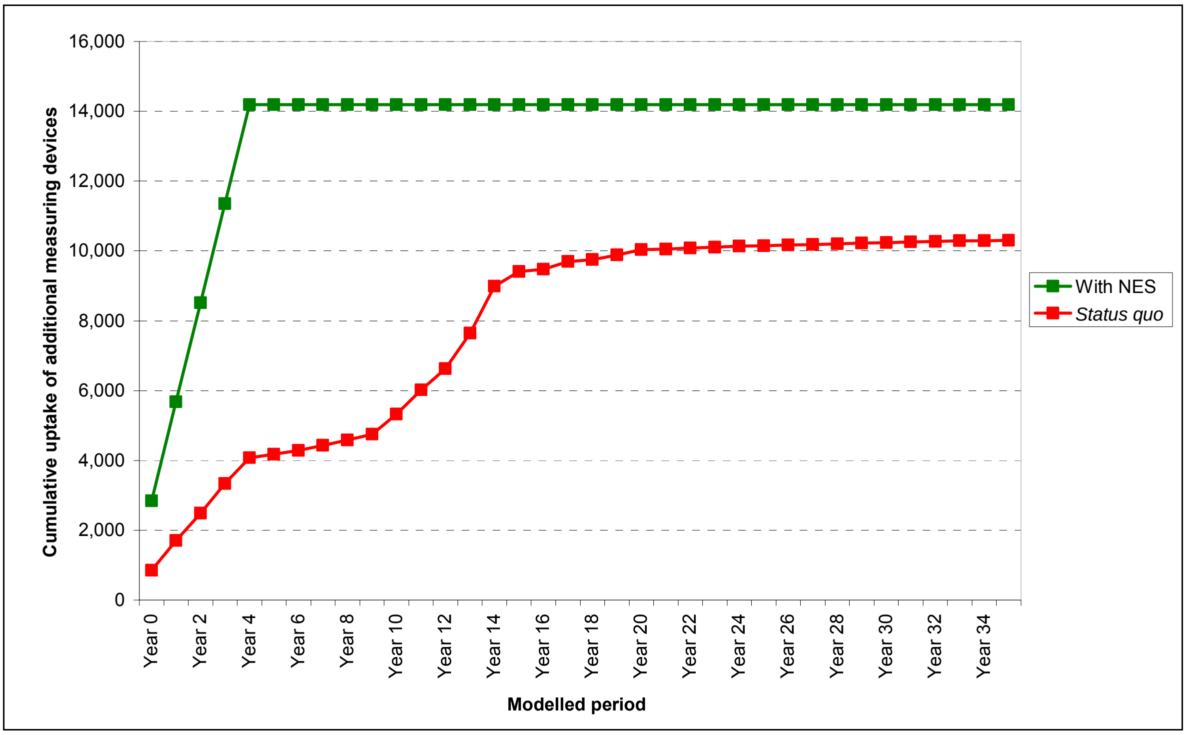
The status quo results in some 10,300 water-measuring devices being installed over a 36-year period. The proposed NES results in approximately 14,200 water-measuring devices being installed over a five-year period subsequent to the gazetting of the regulation. This assumes that 20 percent of existing measuring devices do not meet the standard and that the proposed NES results in all unmeasured takes possessing measuring devices within five years of gazetting the regulation.

Figure 4 illustrates the uptake of water-measuring devices under the status quo and the proposed NES scenario. The increase in the uptake (year 10 to year 15) of measuring devices under the status quo results from ECan's proposed NRRP becoming operative

[42] Stakeholder submissions also raised concerns about the ability of some existing meters to interface with data loggers. This has been addressed through clarification that the standard does not specifically demand the use of a data logger: the standard merely demands that an auditable log be kept and reported to council (Water Measuring Devices NES reference group, Minutes #7, March 2007).

within five to six years and measuring devices being installed over the following five to ten years.

Figure 4: Uptake of water-measuring devices under the status quo and proposed NES



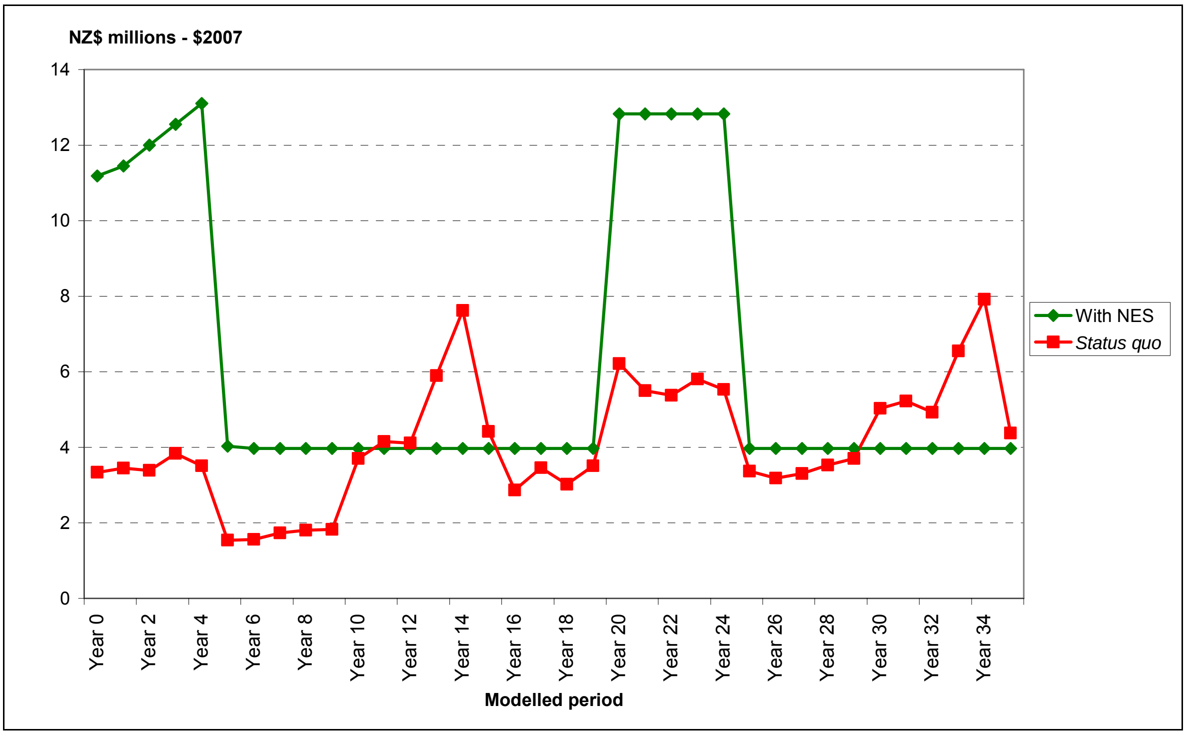
5 RESULTS AND SUMMARY

The costs and benefits of the proposed NES are largely associated with differences in the extent to which measuring devices are required and the timeframe for consents to include a water-measurement device. The NES proposes that these devices be installed within five years. Under the status quo many regional councils already require that new water consents be measured and that existing consents be measured upon replacement. Modelling of the status quo assumes that water-measuring devices will be installed upon consent replacement, and in the case of Canterbury under consent review processes and the implementation of an operative NRRP. Exemptions under the status quo will generally be associated with smaller take rates except for the West Coast, where all consented takes are assumed to be exempt from measurement. Under the proposed NES no takes are exempted from measurement.

5.1 Present value of costs

The uptake of water-measuring devices under the status quo and the proposed NES is modelled over a 36-year time horizon. Figure 5 details the timing of the costs associated with the capital purchase of measuring devices, ongoing costs (five-yearly calibration and annual reporting), replacement cost at year 20 and consent review costs associated with the two scenarios.

Figure 5: Timing of costs − capital, ongoing, replacement and consent review costs



A discounted cash flow approach (discount rate of 10 percent) has been used to derive the present value (PV) of the cost of the two scenarios. The additional costs attributable to the proposed NES equate to the difference between the present value (PV) of the costs of the individual scenarios:

PV cost of NES = PV costs proposed NES minus *PV costs status quo.*

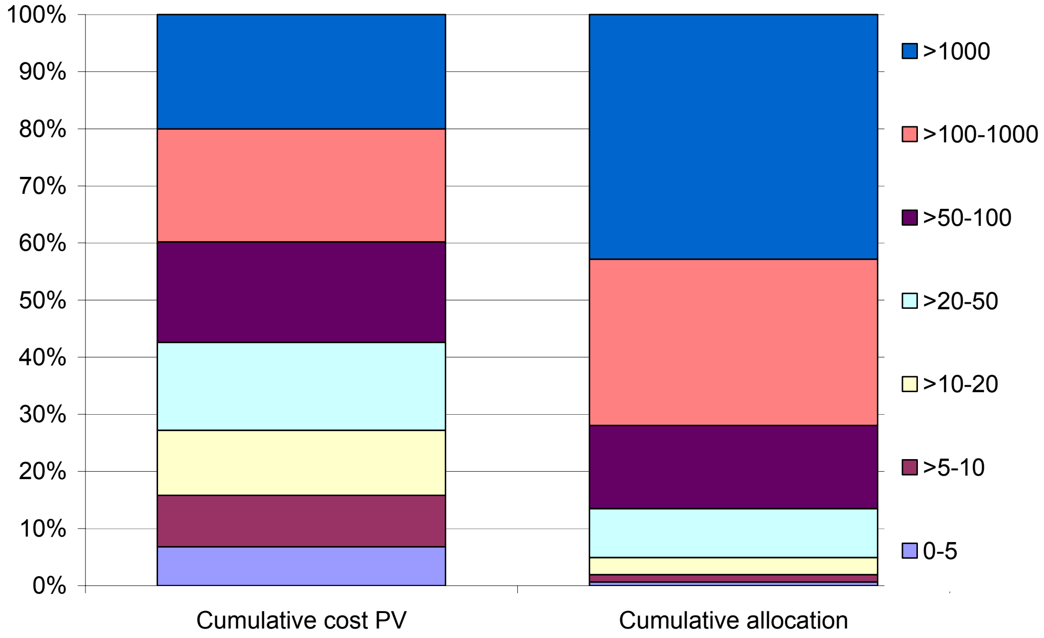
The present value of capital, ongoing, replacement and consent review costs of the proposed NES is estimated to be $42.3 million (Table 18). Approximately 57 percent of the $PV_{10\%}$[43] of cost is associated with the measurement of takes of less than 20 L/s. These takes account for just 8 percent of the estimated unmeasured annual allocation (see Figure 6). The large proportion of cost (34 percent) associated with takes of less than 5 L/s arises because of the large number of consents and the assumption that under the status quo currently unmeasured takes of this size are exempt by many councils from the requirement to instal measuring devices.

Table 18: PV cost of NES by take rate − capital, ongoing, replacement and consent review costs

Take rate litres per second	Unmeasured annual allocation (Millions m^3/annum)	Number of affected consents	$PV_{10\%}$ cost of NES ($million)	% unmeasured annual allocation	% PV cost
0−5	160	4,720	$14.3	2	34
>5−10	134	1,756	$4.7	2	11
>10−20	286	2,145	$5.1	4	12
>20−50	963	3,213	$8.5	13	20
>50−100	1,006	1,412	$4.5	14	11
>100−1,000	2,538	886	$4.7	34	11
> 1,000	2,353	53	$0.6	32	1
Total	**7,440**	**14,184**	**$42.3**	**100**	**100**

[43] $PV_{10\%}$ – Present Value – Discount rate 10%

Figure 6: Cumulative $PV_{10\%}$ of costs (capital, ongoing, replacement and consent review costs) and cumulative allocation



On a regional basis, the Canterbury region (ECan) accounts for 36 percent of the cost of the proposed NES and 49 percent of the total unmeasured annual allocation (Table 19). The Hawke's Bay and Otago regions each account for 12 percent of the cost. This reflects both the number of consented water takes and the current situation with regard to the uptake of water-measuring devices in these regions. The West Coast region features relatively prominently (5 per cent of the cost of the NES) because it is assumed under the status quo that there is no uptake of measuring devices.

Table 19: PV$_{10\%}$ cost of NES by region − capital, ongoing, replacement and consent review costs

Region	Annual allocation Millions m^3/annum	Number affected consents	PV$_{10\%}$ cost of NES $million	% Unmeasured annual allocation	% PV cost
Northland	94	494	$1.5	1	4
Auckland	50	284	$1.3	1	3
Waikato	382	470	$1.0	5	2
Bay of Plenty	398	988	$3.1	5	7
Gisbourne	59	32	$0.2	1	0
Taranaki	34	64	$0.2	0	1
Hawke's Bay	393	2,234	$5.1	5	12
Manawatu-Wanganui	162	448	$1.1	2	3
Greater Wellington	593	469	$1.4	8	3
Tasman	96	821	$2.5	1	6
Nelson	29	33	$0.0	0	0
Marlborough	79	549	$1.4	1	3
West Coast	271	432	$2.2	4	5
Canterbury	3,663	5,358	$15.3	49	36
Otago	1,058	1,182	$4.9	14	12
Southland	80	324	$1.1	1	3
Total	**7,440**	**14,184**	**$42.3**	**100**	**100**

The additional cost of the implementation package proposed by the Ministry for the Environment adds approximately $1.2 million to the total cost of the proposed NES. The total $PV_{10\%}$ cost of the proposed NES is therefore estimated at $43.5 million. Ninety-six per cent ($41.8 million) of the cost will be incurred by existing consent holders, while regional councils and central government will incur 3 percent ($1.1 million) and 1 percent ($0.6 million) respectively (Table 20).

Table 20: $PV_{10\%}$ cost of NES, by stakeholder group

Affected group	Cost item	$PV_{10\%}$ cost of NES $million
Existing consent holders	Capital and installation costs	$21.7
	5-year costs (calibration/replacement mechanical register)	$3.8
	20-year replacement costs	$3.2
	Annual costs	$13.1
	Total cost	**$41.8**
Regional councils	Consent review cost	$0.5
	Implementation package	$0.6
	Total cost	**$1.1**
Central government	Implementation package	$0.6
Total Cost		**$43.5**

5.2 Potential benefit

A number of important benefits arising from the NES have been identified through discussions with stakeholders, including the following.

- There is almost universal agreement among stakeholders that the measurement of actual consented water take will improve the management of New Zealand's freshwater resource. The potential for improved management of the resource through knowledge of consented water take is delayed under the status quo. Existing studies indicate that New Zealand residents can place high value on the protection of the natural environment, and on this basis it is reasonable to assume that improvements in the management of freshwater resources and environmental flows will be accorded a high value by New Zealand residents.

- Compliance monitoring and enforcement in the absence of water-measuring devices is so imprecise and inaccurate as to only be useful for blatant non-compliance, such as that occurring during times of restriction. The NES does not require the monitoring of take rate, and in some situations this may limit the extent to which it assists in improved compliance monitoring.

- There will be improved confidence in water resource management that is informed by the measurement of consented water take. The value of improved public confidence may result in reduced transaction costs in resource decision-making.

- The proposed NES will improve the ease and effectiveness with which actual water take can be reported. Measurement of take is an important condition for achieving and demonstrating improved efficiency at all levels (individual, industry, regional and national). At a national level, the proposed NES will allow for the compilation of complete physical water accounts within five years of the regulation being gazetted. This will assist in the understanding of the effects of environmental policy on the economy, and economic policy on the environment. It will also help the nation to meet its international obligations to report the status of and changes to its natural environment.

- Technical efficiency gains accruing to existing consent holders from enhanced systems performance monitoring and management have not been quantified. Stakeholder interviews and the cited literature suggest that there can be benefits derived by consented water users monitoring actual water taken, which in some situations may offset the cost of installing and maintaining a water-measuring device.

- There is the potential for allocative efficiency gains resulting from the knowledge of actual consented water take. Such benefits only arise where water is scarce. In the absence of data describing actual take, the determination of reasonable needs of consented water users is based on relatively simple models, and the degree to which a resource is allocated is often based on these same models. Because the models used for estimating take are reasonably coarse, the availability of data describing actual take creates significant potential for allocative efficiency gains. Such gains may arise through:

    - identification of un-utilised allocation
    - refinement of estimates of the degree of effective catchment allocation
    - improved resource understanding, allowing for less conservatism in the setting of allocated volume at the catchment level.

- The refinement of allocation through the knowledge of actual take − implementation mechanisms aside − has the potential to free up water in catchments that are considered to be highly allocated.

5.2.1 Present value of the potential allocative efficiency gain

The potential for allocative efficiency gains resulting from the knowledge of actual consented water take have been identified. Allocative efficiency gains only arise where water is scarce. They do not arise where water is abundant, because water users can simply apply and gain consent to take water for consumption.

The quantification of the benefit arising from allocative efficiency gains has been carried out for a scenario whereby irrigators are able to increase their level of consumptive take. The potential for allocative efficiency gains may not accrue solely to irrigators, however. Other potential beneficiaries include municipal water supplies, industrial users and the environment. The level of benefit identified is illustrative only and cannot be attributed solely to the installation of water-measuring devices (Table 21). The implementation approach taken is also critical to realising the benefits claimed. The allocative efficiency benefit enabled by the proposed NES results from benefits arising earlier than they otherwise might.

Table 21: $PV_{10\%}$ of potential benefit resulting from improvement in allocative efficiency

Level of increase in consumptive water use through improved allocative efficiency in highly allocated regions	**2.5%**	**5.0%**	**7.5%**
$PV_{10\%}$ benefit arising from improved allocative efficiency and consumption by irrigators ($million)	$31.8	$63.6	$95.5

The results suggest that if the installation of water-measuring devices enables a 3.4 percent increase in consumptive take for irrigation purposes in what are currently considered highly allocated regions, the benefits will outweigh the costs of the proposed NES. The benefits illustrated would accrue to existing irrigators who can exploit the knowledge (e.g. through increasing irrigable area) that they are not fully utilising their consented allocation, or to potential irrigators seeking consents in catchments that are considered to be highly allocated. However, the increased use of water for consumptive purposes may have some offsetting costs for in-stream values, water quality and green-house-gas emissions due to the intensification of land use.

Allocative efficiency gains could equally arise as environmental flows. Under this scenario, councils will have determined that the value of water as environmental flows is equal to or greater than its value as consumptive use.

5.3 Sensitivity analysis

Stakeholder interviews have consistently raised two themes in relation to the implementation of the proposed NES:

- whether there is a need for the *comprehensive* measurement of consented water take (all takes measured in all situations)
- the logistical challenge of installing in excess of 14,200 measuring devices in the proposed five-year time frame in the face of human resource constraints.

Several regional councils and other parties have submitted that regional councils should maintain discretion as to when and where measuring devices are required. They maintain that little benefit is to be gained by requiring measurement in regions/catchments where consented abstraction is a small proportion of the total available resource. Some councils have suggested that small takes only require measurement where a resource is highly allocated, or where the cumulative effect of smaller takes is significant.

For example, the West Coast Regional Council maintains that their region has an abundant water resource and that demand pressure is low in relation to the extent of the available resource. There is provision in their regional plan for requiring the installation of a water-measurement device if deemed necessary by the council. It is estimated that 5 percent of the cost ($PV_{10\%}$ cost \$2.2 million) of the proposed NES is associated with the West Coast region. (See Annex III for further detail.)

The cost of the proposed NES is sensitive to an assumed threshold for measurement. On a national basis, it is estimated that 44 percent of the cost ($PV_{10\%}$ cost \$19 million) of the NES is associated with take rates of less than 10 L/s and that these takes account for 4 percent of the total unmeasured annual allocation by volume. The large proportion of the total cost (34 percent) associated with takes of less than 5 L/s arises because of the large number of consents and the assumption that under the status quo many councils currently exempt unmeasured takes of this size from the requirement to instal measuring devices. Approximately 57 percent of the cost is associated with the measurement of takes of less than 20 L/s. These takes account for just 8 percent of the estimated unmeasured annual allocation.

Submissions and key informant interviews have repeatedly raised concern regarding the industry's ability to instal approximately 14,200 water-measuring devices over a five-year period. The concerns raised focus on constraints on physical infrastructure and on trained and competent staff. Submitters and key informants believe that in the face of these constraints and a lack of industry accreditation/certification, quality issues in relation to measuring devices and installation are likely to compromise the accuracy standards sought under the proposed NES. If the proposed timeframe for achieving comprehensive measurement of consented water takes was extended to 10 years following gazetting of the regulation, the $PV_{10\%}$ cost would be reduced by 34 percent from ≈\$43.5 million to ≈\$28.6 million.

The Ministry for the Environment has raised the prospect that the bulk supply of measuring devices the proposed NES might necessitate could lead to a reduction in the cost of these devices. Interviews with suppliers suggest that although significant discounts could be possible, they are reluctant to disclose the extent of any discount at this stage of the proceedings.

The sensitivity of costs and benefits to changes in key inputs is described in Tables 22 and 23 respectively.

Table 22: PV cost of NES, $million − sensitivity to changes in key inputs

Input	Range	Discount rate, $million		
		5%	10%	15%
Implementation time frame	5 years – base case	$55.9	$43.5	$36.4
	10 years	$40.3	$28.6	$21.7
Non-complying existing water-measuring devices	10%	$50.6	$40.0	$33.8
	Base case − 20%	$55.9	$43.5	$36.4
	30%	$61.2	$46.9	$39.0
NES threshold	Without ECan NRRP	$68.7	$49.8	$39.8
	Exemptions as per modeling of status quo	$36.4	$30.8	$26.9
	> 5 L/s	$34.9	$29.2	$25.3
	> 10 L/s	$28.7	$24.5	$21.4
	> 20 L/s	$22.6	$19.4	$17.1
Bulk discounts	10%	$54.0	$41.3	$34.2
	20%	$52.0	$39.1	$32.0
All costs	−10%	$50.4	$39.2	$32.9
	+10%	$61.3	$47.7	$40.0

The level of benefit identified is illustrative only, and cannot be attributed solely to the installation of water-measuring devices.

Table 23: PV benefit, $million − sensitivity to changes in key inputs

Input	Range	Discount rate, $million		
		5%	10%	15%
Implementation time frame	5 years − base case	$130.2	$63.6	$33.1
	10 years	$87.4	$39.0	$18.7
Allocative efficiency gain – increase in consumptive water use by irrigation	2.5%	$65.1	$31.8	$16.6
	5.0% − base case	$130.2	$63.6	$33.1
	7.5%	$195.3	$95.5	$49.7
	Allocative efficiency gain required to outweigh costs of the NES	2.1%	3.4%	5.5%

5.4 Summary

Table 24 provides a summary of the costs and benefits identified, along with their magnitude.

Table 24: Magnitude of costs and benefits summarised

			Magnitude	Affected group
Cost	$PV_{10\%}$ cost of NES	Quantified	$41.8 million	Existing consent holders
			$1.1 million	Regional council
			$0.6 million	Central government
	Total $PV_{10\%}$ cost of NES		**$43.5 million**	
Benefit	Management of freshwater resources	Qualitative	Improved	Regional council and the wider regional community
	Determination of environmental flows	Qualitative	Improved	Regional council and the wider regional community
	Compliance monitoring	Qualitative	Significantly improved	Regional council, consent holders and the wider regional community
	Transaction costs at consent application	Qualitative	Possible reduction	Regional council, consent applicants and the wider regional community
	Technical efficiency	Qualitative	Can contribute to the derivation of benefit in some situations	Consent holders
	Allocative efficiency	Quantified	Significant (e.g. if it enabled a 3.4% increase in consumptive water use by irrigation, the benefits would outweigh the costs of the NES)	Applicants for new consents and existing consent holders, where the latter are able to exploit the knowledge that they are not fully utilising their consented allocation
	Reporting and understanding actual water take	Qualitative	Significantly improved	Regional council, central government, consent holders and consent applicants

5.5 Data qualifications

The analysis presented has relied on the water allocation consent database prepared for the Ministry for the Environment by Aqualinc (2006a, 2006b, 2006c). This database describes all consented water takes in terms of take rate, annual allocation, outlet type, primary use, consent expiry date, etc. The database does not, however, describe whether or not an individual consent is subject to measurement. This is achieved through the analysis "of the number of consents without measuring devices and assumes that the current distribution of metered consents is similar to the distribution of take rates" (Aqualinc, 2006b). Time and resources allocated to the preparation of the cost–benefit analysis did not allow for this limitation to be addressed. Although the Ministry consents database represents the best available information at the time of writing, Harris Consulting can not accept any responsibility for data limitations associated with this database.

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ANNEX I: KEY INFORMANTS

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ANNEX II: GDP ESTIMATES FOR IRRIGATION AND NET BENEFIT ADJUSTMENTS

Table A1: Net contribution of irrigation to farm gate GDP

Region	Area irrigated ha	Total value of irrigation GDP million	Value of irrigation GDP/ha/annum
Northland	7,000	$29	$4,110
Auckland	7,900	$54	$6,880
Waikato	14,500	$56	$3,840
Bay of Plenty	11,400	$39	$3,440
Gisborne	5,600	$25	$4,530
Hawke’s Bay	18,100	$99	$5,480
Taranaki	2,900	$6	$2,070
Manawatu−Wanganui	8,000	$21	$2,620
Wellington	9,600	$21	$2,270
Tasman	10,000	$47	$4,660
Marlborough	20,200	$86	$4,250
Canterbury	287,200	$335	$1,170
Otago	68,900	$87	$1,270
Southland	4,100	$13	$3,170
Totals:	**475,700**	**$920**	**$1,930**

Table A2: Labour cost adjustments to GDP estimates − $/ha/annum

Region	Dairy	Sheep and beef	Deer	Arable
Northland	$4	$18	$51	$111
Auckland	$4	$18	$51	$111
Waikato	$277	$33	$51	$111
Bay of Plenty	$277	$33	$51	$111
Gisborne	$141	$114	$51	$111
Hawke's Bay	$141	$114	$51	$111
Manawatu−Wanganui	$141	$114	$51	$111
Taranaki	$141	$114	$51	$111
Wellington	$141	$114	$51	$111
Tasman	$590	$47	$41	$111
Marlborough	$590	$47	$41	$111
Canterbury	$590	$47	$41	$111
Otago	$538	$31	$41	$111
Southland	$538	$31	$41	$111

Source: Various MAF Farm Monitoring Reports, 2004

Table A3: Transition capital costs associated with land-use change to irrigation

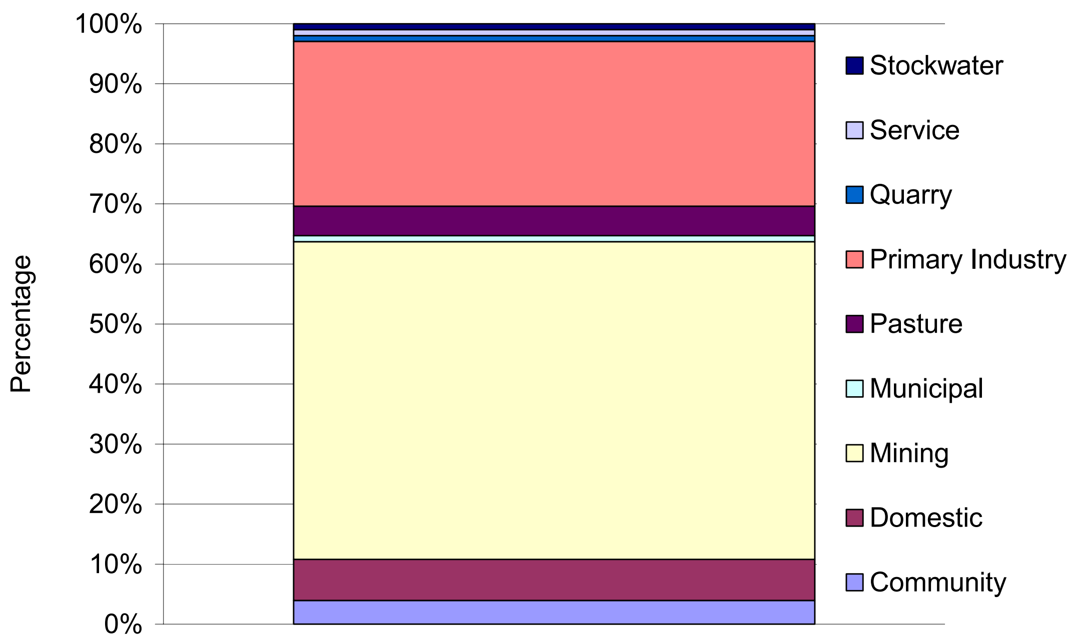
Land use	Capital costs $/ha
Dairy	$12,500
Sheep and beef	$1,000
Deer	$3,500
Arable	$500
Horticulture	$30,000
Viticulture	$20,000

ANNEX III: WEST COAST REGIONAL COUNCIL

By national and international standards, the West Coast region receives a generous and reliable rainfall. Near the Main Divide this exceeds 8,000 mm annually and declines to 2,000 mm at the coast. The mid- to upper Grey Valley possesses the lowest rainfall in the region (West Coast Regional Council, 2005). The West Coast Regional Council (WCRC) reports that issues associated with highly allocated catchments and aquifers are not yet experienced on the West Coast due to the quantity of the region's resource and low demand pressures. The council maintains that as a water-rich region with low demand, the proposed NES "has little relevance for the West Coast in terms of any need to improve water management".[44] A limited number of takes are currently measured.[45]

The Ministry for the Environment's consent database suggests that the total annual allocation of consented water takes on the West Coast is 271 million m^3/annum, 90 per cent of which is sourced from surface water. Fifty-four per cent of consented water take is associated with the mining industry (Figure A1). The WCRC reports that although water take by the mining industry is consented, it is not consumptive because it is primarily related to "dredge ponds" and is returned to the environment following settling.[45] If mining is ignored, consumptive take on the West Coast is 127 million m^3/annum, just 1.3 percent of the national consented annual allocation (≈ 9,908 million m^3/annum) of water take.

Figure A1: Consented abstraction, by use type



[44] West Coast Regional Council, submission on proposed NES.
[45] Simon Moran, West Coast Regional Council, July 2007.

We estimate that as a result of the proposed NES, the West Coast region will incur a $PV_{10\%}$ cost of $2.2 million. This is approximately 5 per cent of the total national cost of the proposed NES. No benefits associated with the potential improvement in allocative or technical efficiency have been identified.