Implications of the Proposed National Environmental Standard on Ecological Flows and Water Levels for the Gisborne District

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Prepared for

Gisborne District Council

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Executive Summary

Gisborne District Council (GDC) requested NIWA to provide advice on managing ecological flows (for rivers) and water levels (for groundwater) in the District, with specific regard to the Proposed National Environmental Standard on Ecological Flows and Water Levels (NES) (MfE 2008). This work was carried out under two Envirolink Small Advice Grants from the Foundation for Research Science and Technology.

The proposed NES provides a set method for establishing interim limits on the alteration of flows in rivers and levels in groundwater systems, for situations where no limits are yet set in a proposed or operative regional plan. While GDC administers a number of existing surface water take consents that have conditions controlling abstraction at an identified minimum river flow, there is no regional water plan for the District and the NES therefore applies in this situation. The set method of the proposed NES uses basic information such as the river flow statistic mean annual low flow (MALF), the average annual aquifer recharge, and knowledge of the volume of water allocated by existing resource consents. The proposed NES also provides a process for selecting the appropriate technical methods for evaluating the ecological component of environmental flows and water levels, for use in setting appropriate limits on flows and levels in regional plans.

This report covers three questions: 1) What will the NES mean for GDC, in general terms, if it comes into force?; 2) What will the NES interim limits be for GDC's main water resources in the short term?; and 3) What methods could GDC employ to establish locally-specific limits for ecological flows and water levels for a regional plan in the long term?

1) *What the NES means for GDC*

GDC currently manages water takes from rivers and groundwater by issuing resource consents under the Resource Management Act (RMA) and the terms of its Transitional Regional Plan. GDC does not have an operative or proposed regional water plan. Therefore the proposed NES and its interim limits for ecological flows and water levels will apply in the Gisborne District, if and when the NES comes into force. This is useful for GDC because it provides an interim framework for managing water allocation for the short term, while providing flexibility and guidance for GDC to develop its own locally customised regional water plan in the medium and long term.

2(a) *Interim limits for the Waipaoa River*

Under the proposed NES, interim limits for the Waipaoa River (GDC's main river resource) would be:

(i) A minimum flow of 2,080 L/s (2.08 m^3/s) - this being 80% of the mean annual low flow (MALF)[1].

(ii) An allocation limit of 2,497 L/s (2.497 m^3/s or 140,952 m^3/day) - this being the current total allocation in the catchment in terms of existing resource consents for surface water takes.

2(b) *Interim limits for groundwater, e.g., the Makauri aquifer*

Under the proposed NES, interim limits for the five aquifers of the Poverty Bay Flats (e.g., Makauri aquifer – GDC's main groundwater resource) would need to be based on the current total allocation for each aquifer because the average annual recharge is unknown. The interim limits would be:

(i) For the Makauri aquifer (for example) an allocation limit of 1.5 million $m^3/year$ - this being the current total allocation in terms of existing resource consents for groundwater takes from that aquifer. Limits for the other four aquifers (Te Hapara Sand, Shallow Fluvial, Waipaoa Gravel and the Matokitoki) would similarly be their current allocations.

(ii) A requirement to observe the interim minimum flow of 2,080 L/s for the Waipaoa River. This means groundwater takes that affect flow in the Waipaoa River (i.e., are hydraulically connected) would need to reduce or cease when the Waipaoa River is at or below its interim minimum flow.

3) *Methods for determining ecological flows and water levels for a regional plan in the long term*

Application of the process in the proposed NES for selecting technical methods leads to the following recommended methods:

(i) For the Waipaoa River the methods should include consideration of; i) generalised habitat models; ii) 1D hydraulic habitat models; iii) connectivity/fish passage methods; and iv) a periphyton biomass model. These are also suitable methods for the next most utilised river, the Te Arai River.

(ii) For aquifers of the Poverty Bay Flats, lack of knowledge about average annual recharge means that we cannot properly apply the proposed NES methods selection process. Determining robust estimates of average annual recharge for these aquifers is the next logical step towards identifying appropriate methods.

[1] Note that this is based on a MALF of 2,600 L/s as currently estimated using data from the GDC flow recorder at Kanakanaia. There is a second flow recorder near this site and it would be useful to confirm MALF by reviewing data from both recorders.

Conclusions and recommendations

Existing monitoring data suggests that use of surface water and groundwater in the Gisborne District is occurring generally at environmentally sustainable levels. However existing consents for surface and groundwater takes have conditions that allocate an annual volume of water 'on paper' that is significantly greater than the volume of water that is usually actually taken (i.e., in a typical year), needed (i.e., to cover drought years), or indeed even available (i.e., replenished by recharge) in the case of groundwater.

The allocation 'on paper' is used in the proposed NES process and appears in the interim limits defined in 2(a) and 2(b) above. As a result, if the proposed NES came into force today, the interim limits would effectively deny any further allocation of Waipaoa River surface water or Makauri aquifer groundwater to new consent applicants.

Under the proposed NES, the interim minimum flow of 2,080 L/s for the Waipaoa River is greater than the minimum flow of 1,300 L/s currently referred to in the conditions of water take consents. This is likely to create confusion and potentially tension between existing consent holders and any future applicants after the NES comes into force. It is highly desirable for GDC to undertake its own investigations to establish an appropriate minimum flow for the Waipaoa River that can be incorporated into a regional plan and thus supersede both the NES interim minimum flow and the current consent conditions.

We recommend that GDC prepare for the situation where it may need to adopt the interim limits of the proposed NES in the short term. For this we specifically recommend:

(i) Review hydrological data and confirm MALF for the Waipaoa and Te Arai Rivers; and

(ii) Determine robust estimates for average annual recharge for the five Poverty Bay aquifers.

We also recommend that GDC begin work towards producing a regional water plan that does, amongst other important elements of a regional plan, the following:

(iii) Sets locally-specific ecological minimum flows in the Waipaoa and Te Arai Rivers, developed in accordance with the methods outlined in 3(i) above;

(iv) Sets sustainable allocation volume limits for water takes from rivers, that protect other important aspects of ecological flows than the minimum flow;

(v) Sets sustainable allocation volume limits for the five aquifers of the Poverty Bay Flats, by first identifying the average annual recharge for these aquifers and then using other suitable methods recommended in the proposed NES;

(vi) Identifies which aquifers are linked to surface flow in rivers (e.g., the Waipaoa and Te Arai Rivers) and applies the minimum flow set for those rivers to any groundwater takes from the linked aquifers; and

(vii) Allows for a process to review the conditions of existing consents (under s128 of the RMA) to bring the current allocation 'on paper' into line with the volume of water that is actually needed and available according to the allocation limits identified in the regional plan.

1. Introduction

1.1. Background

Gisborne District Council (GDC) requested NIWA to provide advice on managing ecological flows (for rivers) and water levels (for groundwater) in the District, with specific regard to the Proposed National Environmental Standard on Ecological Flows and Water Levels (NES) document released for public discussion in March 2008 (MfE 2008). This work was carried out under two Envirolink Small Advice Grants from the Foundation for Research Science and Technology.

1.2. Purpose

The advice provided in this report covers three questions:

(i) What will the NES mean for GDC, in general terms, if it becomes operative?

(ii) What will the NES interim limits on alterations to flows and water levels be for GDC's main water resources (the Waipaoa River and the Makauri aquifer) in the short term?

(iii) What methods could GDC employ to establish locally-specific limits for ecological flows and water levels for a regional plan in the long term?

1.3. Method

This report covers surface water resources (rivers) and groundwater resources (aquifers) in the Gisborne District. Preparation of this report has included:

(i) A workshop to discuss GDC's current situation with regard to available information on ecological flows and water levels. Participants were; Ned Norton (NIWA) and GDC staff Kerry Hudson, Dennis Crone, Keriana Wilcox, Paul Murphy, Lynette Brown and Greg Hall;

(ii) A field visit to observe rivers in the Poverty Bay Flats area including the Waipaoa River (at Wharerata, Waipaoa and Te Karaka), the Te Arai River at Manutuke, the Waikohu River, the Mangatu River, the Waihora River at Kanakanaia.

(iii) Consideration of available data provided by GDC staff, on GDC's website, in GDC State of Environment Reports, in the NIWA Freshwater Fish Database (NZFFD) and in Gordon (2001) and Barber (1993).

(iv) The focus of this report is on the Waipaoa River and the groundwater resources of the Poverty Bay Flats (e.g., the Makauri Aquifer) because these are by far the most heavily utilised water resources in the District and thus warrant primary attention. Other smaller, less utilised water resources should be included as part of the wider scope of preparing a regional water plan in future.

2. What the proposed NES means for GDC

GDC currently manages water takes from rivers and groundwater by issuing resource consents under the Resource Management Act (RMA) and Transitional Regional Plan. GDC does not have an operative or proposed regional water plan. Therefore the interim limits for ecological flows and water levels in the proposed NES will apply to GDC if and when the NES becomes operative. This is useful for GDC because it provides an interim framework for managing water allocation for the short term, while providing flexibility and guidance for GDC to develop its own locally customised framework in the long term.

It will become clear in the following sections that GDC's water allocation by existing resource consents is at present broadly consistent with the proposed NES interim limits. The (former) East Cape Catchment Board introduced compulsory metering of all consented water takes and set some allocation thresholds such as the minimum flow of 1300 L/s (at which water take restrictions can be imposed) for the Waipaoa River measured at Kanakanaia. In general terms the demand for water has not historically challenged supply. The District's climate has usually provided sufficient rain at intervals over the summer, so that current levels of abstraction have generally been sustainable. This is an enviable position for GDC to be in because many parts of New Zealand have recently experienced a major increase in demand for water for irrigation (and other uses such as hydro-generation). In some areas demand has at times approached or exceeded supply, leading to intense competition for water, reduced reliability of supply, increased pressure on instream values (e.g., ecological values) and possibly reduced water quality in rivers and groundwater as a result of intensified land-uses. This situation has challenged the resources of regional councils and in some cases has forced councils to develop under pressure, increasingly complex planning frameworks for managing water allocation. There is an opportunity for GDC to benefit from the lessons learned in some other regions.

The proposed NES represents an opportunity for GDC to safe-guard its current apparently sustainable position by implementing the NES interim limits, while beginning work on a regional water plan that contemplates a future where demand might challenge supply in the District.

3. Using the NES interim limits for the short term

3.1. Proposed interim limits for rivers

The proposed NES sets interim limits for rivers that include a *minimum flow* and an *allocation* cap, both numbers being derived from a proportion of the river flow statistic 'mean annual low flow' commonly known as MALF. A copy of the proposed interim limits is provided in Appendix I.

3.1.1. Current situation in the Waipaoa River

The Waipaoa River is the main source for surface water abstractions in the District and is therefore the focus for this report. The Waipaoa River (at Kanakanaia has a mean flow of 31.567 m^3/s, a median flow of 14.862 m^3/s and a MALF of 2.6 m^3/s or 2,600 L/s. Existing permit holders who take water from the Waipaoa River currently are subject to a consent condition requiring that abstraction be at the discretion of the District Conservator, should the flow drop below a minimum flow of 1300 L/s (GDC (2007)[2].

There are currently 31 water permits to take surface water from the Waipaoa River. The maximum potential take from the river (i.e. the current total *allocation*) is shown in Table 1.

It is important to consider that the current total *allocation* (on paper) is very unlikely to ever be taken all at one time. To begin with, takes for frost protection are unlikely to occur during summer low flow periods when irrigation demand is greatest. In addition, the allocated maximum take rate for irrigation appears to be much greater than what is usually actually taken. The crop-specific nature of most consents means that water is not generally taken at the maximum consented rate for 24 hours a day all year. GDC has done some work on this and has identified, for example, that actual water usage over the irrigation season from 1 October 2006 to 1 April 2007 was only 19,866 m^3/day – thus only 26% of the 76,000 m^3/day allocated for irrigation was actually used

[2] We have not reviewed existing consent conditions or the basis for the 1300 L/s minimum flow.

in that season. For the 2008/09 irrigation season GDC's work suggests that somewhere in the order of 60% of the allocated water was actually taken.

Table 1: Consented water takes from the Waipaoa River (data supplied by GDC).

	No. of permits	Water use	Allocated volume that can be taken per day (m^3/day)	Maximum rate of take (L/s)
	2	Augmentation of city supply	26,352	305
	3	Frost protection	38,600	1,142
	26	Irrigation	76,000	1,050
Total- all consents	31	-	140,952	2,497
Total– excl. frost[1]	28	-	102,352	1,355

[1] Note that water is not required for frost protection during the summer low flow period – therefore total takes excluding frost protection takes represent the upper abstraction volume limit (i.e., worst case) during this period.

It will be important for GDC in the long term to identify what proportion of the current allocation is really needed by consent holders to cover their worst-case dry seasons. The reason for this is that if existing consent holders are currently allocated more than they need, there may be more water available for use in the District than it appears. This leads to a lack of transparency in the water management framework and may lead to unjustified restriction of potential future consent applicants. Ideally GDC should undertake work to resolve this situation as part of developing a regional water plan for the long term. This would ultimately involve reviewing the conditions of existing consents and adjusting the allocated maximum take rate to be consistent with actual needs. We will discuss this further in Section 4. For our immediate purpose of identifying interim limits for the Waipaoa River under the proposed NES, it is necessary to use the current total allocation on paper in the calculations, as discussed below.

3.1.2. Proposed NES interim limits for the Waipaoa River

Under the proposed NES (section 5.1.3 – see Appendix I), interim limits for the Waipaoa River are as follows:

(iii) A minimum flow of 2,080 L/s (2.08 m^3/s) - this being 80% of MALF.

(iv) An allocation limit of 2,497 L/s (2.497 m^3/s or 140,952 m^3/day) - this being the current total allocation in the catchment (if the NES came into force at time of writing), and it being greater than 50% of MALF.

3.1.3. Implications of the NES interim surface water limits for GDC

There are at least two key implications for GDC:

(i) The proposed NES interim minimum flow of 2,080 L/s is greater than the minimum flow of 1,300 L/s currently referred to in consent conditions. If and when the NES comes into force, we understand the existing consent conditions will still apply until such time as GDC elects to review those existing consents. However any new consent applications would need to be processed with the new NES-derived limits and the greater minimum flow condition (2,080 L/s) would need to be applied. This is likely to create confusion and potentially tension between existing and future users. On this basis it would be desirable for GDC to undertake its own investigations to establish an appropriate minimum flow for the Waipaoa River that can be incorporated into a regional water plan for consistent management of water allocation in the future. It may be useful for GDC to obtain planning and/or legal advice to check our understanding of the way the NES limits would apply.

(ii) The allocation limit of 2,497 L/s is significantly greater than 50 % of MALF (i.e. 50% of 2,600 L/s is 1,300 L/s) – 50% of MALF being the interim limit proposed in the NES for situations where allocation has not already exceeded this. This suggests that allocation (on paper) in the Waipaoa River may be approaching sustainable limits and this warrants being addressed by development of a regional water plan. However we know that the actual situation is not as pressured as it might appear on paper because when frost protection takes are excluded and actual water use taken into account, the actual water used is significantly less than 50% of MALF. This fortunately means GDC has time to prepare a regional water plan, ideally before actual water use reaches sustainable limits.

3.2. Proposed interim limits for groundwater

The proposed NES sets interim limits for groundwater that include an allocation cap to be derived based on a proportion of the average annual recharge of the aquifer in question. In addition, for any groundwater resource that is hydraulically connected to an adjacent river, the minimum flow set for that river will also apply to management of groundwater takes. A copy of the proposed NES interim limits is provided in Appendix I.

3.2.1. Current situation for aquifers of the Poverty Bay Flats

Information on the groundwater resources of the Poverty Bay Flats has been compiled by Barber (1993) and Gordon (2001). An update on the use of the groundwater resource was provided in GDC (2007). There are five main aquifers used on the Flats; Te Hapara Sand, Shallow Fluvial Deposits, Waipaoa Gravel, Makauri Gravel and the Matokitoki Gravel aquifer (Barber 1993; Gordon 2001). Of these the Makauri aquifer is the most heavily used (GDC 2007).

GDC has a network of monitoring bores and has generally good information on groundwater level fluctuations seasonally, in response to abstractions, and through time since monitoring began in the late 1980s. This information has allowed GDC to observe abstraction drawdown in the Makauri aquifer and recharge (from the Waipaoa River), other interconnected aquifers and percolation of rainwater into the unconfined aquifers. This information has led GDC to conclude that current levels of groundwater abstraction are sustainable at this time (GDC 2007). However this has not always been the case as Barber (1993) reported a steady and continual drop in the recharge hydraulic head in the Makauri aquifer during the 10 years from 1982 to 1992. The recovery in water levels since that time is attributed to wetter climatic conditions (GDC 2007). It is also possible that the impacts of peak water use during the kiwifruit boom of the 1980s contributed to reducing water levels over that period. This situation illustrates the importance of GDC's monitoring programme but also highlights the risks GDC faces - i.e., the sustainability of the resource is exposed to the risks of climate variability, long-term climate change, and any increased future demand. It seems timely for GDC to impose interim limits for groundwater use under the proposed NES and to begin developing a regional water plan.

In order to use the proposed NES interim limits for groundwater it is necessary to know two things:

(i) the current total allocation (i.e., total consented groundwater takes); and

(ii) the average annual recharge of the aquifer(s).

GDC has good information on the current total allocation. There are currently 85 consents to abstract up to a total of 60,980 m^3/day of groundwater from the five Poverty Bay Flats aquifers. If these takes were exercised every day of the year (which is highly unlikely due to seasonal variability in demand) this amounts to a total allocation (on paper at least) of 22.3 million m^3/year. Of these, 33 consents are for takes from the Makauri aquifer and these amount to a maximum of 31,524 m^3/day (11.5 million m^3/year). The larger take consents (those taking more than 10 m^3/day) have generally been issued for five years and some large take consents have conditions that limit the amount of abstraction according to monitored water levels in the aquifer.

However there is currently no complete estimate of average annual recharge for the Poverty Bay Flats aquifers. Existing information that could be used to help estimate average annual recharge is provided in Gordon (2001) and Barber (1993). In the latter report some estimates are provided of the average volume of water flowing through the aquifers. These are:

- Waipaoa Gravel aquifer - 1000 m^3/day,
- Makauri Gravel aquifer – 1300 to 6000 m^3/day,
- Matokitoki Gravel aquifer – 130 to 1000 m^3/day,
- Te Hapara Sand aquifer – 1000 to 3000 m^3/day.

If these estimates are simply scaled up this suggests a coarse estimate of the annual average recharge for the Makauri aquifer (for example) might be in the order of 474,500 to 2.2 million m^3/year. The current consented total annual allocation (on paper at least) from the Makauri aquifer (11.5 million m^3/year) is obviously significantly greater than the most optimistic coarse estimate of average annual recharge derived from Barber (1993). If all of these consented takes were exercised together for the whole year it seems very unlikely that this would be sustainable. This situation is fortunately largely a result of the allocation 'on paper' not reflecting the fact that 'actual takes' occur only for some fraction of the year according to seasonally variable need. In Section 4 of this report we will recommend that GDC ultimately review the conditions of all existing consents (as part of developing a regional plan for the long term) to ensure that the allocation 'on paper' is limited to the actual need. For example, because most takes are issued for specific crops, an estimate of the crop water requirements should be undertaken rather than just assuming the maximum daily take rate multiplied by 365 days per year.

In the short term we recommend that the very next step for GDC's management of groundwater resources should be to develop robust estimates for average annual recharge for the Poverty Bay Flats aquifers so that the proposed NES interim limits for groundwater can be properly applied. In the absence of robust estimates of average annual recharge it would be necessary to assume that the interim NES limit must be the current total allocation as indicated in the next section.

3.2.2. Proposed NES interim limits for the Makauri aquifer

Under the proposed NES (section 5.1.1 – see Appendix I), if it came into force at time of writing, the interim limit for the Makauri Aquifer would need to be based on the current total allocation. The interim limits would therefore be:

(iii) An allocation limit of 1.5 million m^3/year - this being the current total allocation.

(iv) A requirement to observe the interim minimum flow of 2,080 L/s for the Waipaoa River. This means if groundwater takes affect flow in the Waipaoa River (i.e., are hydraulically connected) then they would need to cease at times when the Waipaoa River is at or below the minimum flow.

3.2.3. Implications of the NES interim groundwater limits for GDC

The implications for GDC are

(i) If the proposed NES came into force today the interim limits would effectively deny any further allocation of groundwater to new consent applicants.

(ii) If GDC develops (as we recommend) robust estimates for average annual recharge of the aquifers, and if these estimates show that the currently consented groundwater takes amount to less than 35% of the average annual recharge, then the "35% of average annual recharge" figure will become the new interim NES limit. Under this situation GDC would be in a position to consider granting new consent applications for takes up to the interim limit.

(iii) The current allocation of groundwater by consents 'on paper' appears to be significantly greater than the volume of water 'actually taken'. Until this situation is resolved (by reviewing consent conditions) it seems likely that GDC's current allocation of groundwater resources will appear on paper to be unsustainable. Fortunately GDC's monitoring data shows that this is generally not the case.

4. Preparing a regional water plan for the long term

4.1. Why prepare a regional water plan?

Under the RMA it is not mandatory for councils to prepare regional water plans. GDC could choose to rely on the NES interim limits for processing future resource consent applications on a case-by-case basis. However there are a number of advantages for GDC in preparing a regional water plan. We will discuss two advantages.

One key advantage is that a regional plan would allow GDC to set its own locally-specific limits for ecological flows and water levels rather than continuing to rely on the NES interim limits. The interim limits have been set to be conservative in favour of limiting adverse ecological effects. This was necessary because the developers of the proposed NES had to rely on only the most basic information (e.g., hydrological records and statistics such as MALF) that would be generally available across all parts of the country. If demand for water increases in future (or if climate variability and/or change leads to changes in the availability of the resource) GDC may come under pressure to justify restricting resource use on the basis of the (probably) conservative interim limits. This is particularly likely given that existing resource consent holders benefit from a lower (less environmentally conservative) minimum flow (i.e., 1,300 L/s instead of the NES interim limit of 2,080 L/s) that was set historically, probably relatively arbitrarily[3]. By undertaking a more detailed assessment (see Section 4.3 below), it will be possible for GDC to confirm a set of limits for ecological flows and water levels that will be appropriate and defensible for a regional plan.

A second key advantage is that developing a regional plan (with defensible limits) provides a robust and fair process for reviewing existing consents to bring their conditions into line with the new regional plan. Section 128(1)(b) of the RMA provides the mechanism for this. It is clear from discussion in Sections 3.1.1 and 3.2.1 that current consents for surface and groundwater takes have conditions that allocate an annual volume of water 'on paper' that appears to be significantly greater than the volume of water needed (i.e., in the worst drought year), usually actually taken (i.e., in a normal year), or indeed even available (i.e., replenished by recharge) in the case of groundwater. This makes GDC's current allocation on paper appear environmentally unsustainable when environmental monitoring shows it is probably not. It will be necessary at some stage to review all existing consent conditions to resolve this situation. This situation could cause major difficulties for GDC, as it has for some other regional councils, if demand for water suddenly increases for some reason.

[3] We have not reviewed the basis for the 1,300 L/s minimum flow in the Waipaoa River. GDC staff indicated it was established to protect ecological values but the basis for selecting that flow is unknown (e.g., Dougal Gordon pers. comm. and Kerry Hudson pers. comm.).

4.2. Components of a regional water plan

Preparing a regional water plan involves a broader scope of considerations than just ecological flows and water levels. For example it will be necessary to consider the importance of flow and water levels for a range of values other than ecological values (e.g., cultural, recreational, landscape and amenity values, as well as the use of water for social and economic benefit). It will also be necessary to consider how water quality is affected by ecological flows and water levels, and how water quality influences the full range of values the community holds for its rivers and groundwater resources. These considerations are outside the scope of this report and are being considered separately in a related GDC project.

The next section of this report focuses on recommending methods for GDC to establish locally-specific limits for ecological flows and water levels for a regional plan.

4.3. Methods for determining ecological flows and water levels for a regional plan

The proposed NES was released together with a companion document – the Draft Guidelines for the Selection of Methods to Determine Ecological Flows and Water Levels (Beca 2008). The Beca (2008) guidelines are included in the NES by reference, a process that allows them to be kept up-to-date without changes to the NES. A copy of the Executive Summary and Recommendations from this document is provided in Appendix II.

4.3.1. Methods for rivers

Using the guidelines (Beca 2008), the first step is to determine the "risk of deleterious effect" on instream habitat by identifying the fish species present and the natural mean stream flow (see Table A4.1 provided in Appendix II). The mean flow of the Waipaoa River (at Kanakanaia) is 31.567 m^3/s. The fish species present in the Waipaoa catchment, as recorded on the NIWA Freshwater Fish Database (NZFFD), are shown in the figure and table in Appendix III. From this information and using Table A4.1 the "risk of deleterious effect" in the lower Waipaoa River (where abstraction occurs) is "low", although it is noted that there are species present in the upper catchment that need access to and from the sea at some times of the year via the lower reach of river affected by abstractions (i.e., inanga, redfin bully, common bully, torrentfish and bluegill bully).

The second step is to consider the potential degree of hydrological alteration caused by abstraction. For the Waipaoa River, the current allocated water is more than 40% of MALF (see Section 3.1.3) and this is considered a "high degree of hydrological alteration" in terms of Table A4.2. Note that actual takes are less than this but it is necessary to carry out this assessment based on what is actually allocated.

The third step is to use Table A4.3 to establish the recommended best practice methods to be used in establishing ecological flow requirements for the Waipaoa River. Using a "high degree of hydrological alteration" and a "low – medium significance of instream values" directs us to the bottom left-hand cell of the matrix in Table A4.3, with some consideration of the bottom centre cell. Therefore we recommend the following methods to be considered if and when GDC embarks on a project to set locally-specific ecological flows for the Waipaoa River (Note that detail of these methods is provided in Beca (2008)):

- Generalised habitat models,
- 1D hydraulic habitat model,
- Connectivity/fish passage, and a
- Periphyton biomass model.

When GDC designs the project method in detail (including site visits and selection of survey cross-sections for modelling) the following additional methods (from the bottom centre cell in table A4.3) should also be considered:

- Temperature model,
- Dissolved oxygen model, and
- Suspended sediment.

4.3.2. Methods for groundwater

In order to use the guidelines (Beca 2008) it is necessary to know both the total current allocation and the average annual recharge for the aquifers of the Poverty Bay Flats. As discussed in Section 3.2.1 we currently know the former but do not have robust estimates of the latter. We recommend that the next step for GDC should be to develop robust estimates for average annual recharge for the Poverty Bay Flats aquifers so that:

(i) the proposed NES interim limits for groundwater can be properly applied; and

(ii) appropriate methods can be identified for establishing locally-specific groundwater allocation limits for use in a regional water plan in the long term.

5. Conclusions and summary of recommendations

Existing monitoring data suggests that use of surface water and groundwater in the Gisborne District is occurring generally at environmentally sustainable levels. However existing consents for surface and groundwater takes have conditions that allocate an annual volume of water 'on paper' that is significantly greater than the volume of water that is usually actually taken (i.e., in a typical year), needed (i.e., to cover drought years), or indeed even available (i.e., replenished by recharge) in the case of groundwater

The allocation 'on paper' is used in the proposed NES process and appears in the interim limits determined in section 3.1.2 and section 3.2.2. As a result, if the proposed NES came into force today, the interim limits would effectively deny any further allocation of Waipaoa River surface water or Makauri aquifer groundwater to new consent applicants.

Under the proposed NES, the interim minimum flow of 2,080 L/s for the Waipaoa River is greater than the minimum flow of 1,300 L/s currently referred to in the conditions of water take consents. This is likely to create confusion and potentially tension between existing consent holders and any future applicants after the NES comes into force. It is highly desirable for GDC to undertake its own investigations to establish an appropriate minimum flow for the Waipaoa River that can be incorporated into a regional plan and thus supersede both the NES interim minimum flow and the current consent conditions.

We recommend that GDC prepare for the situation where it may need to adopt the interim limits of the proposed NES in the short term. For this we specifically recommend:

(i) Review hydrological data and confirm MALF for the Waipaoa and Te Arai Rivers; and

(ii) Determine robust estimates for average annual recharge for the five Poverty Bay aquifers.

We also recommend that GDC begin work towards producing a regional water plan that does, amongst other important elements of a regional plan, the following:

(iii) Sets locally-specific ecological minimum flows in the Waipaoa and Te Arai Rivers, developed in accordance with the methods outlined in section 4.3.1 above;

(iv) Sets sustainable allocation volume limits for water takes from rivers, that protect other important aspects of ecological flows than the minimum flow;

(v) Sets sustainable allocation volume limits for the five aquifers of the Poverty Bay Flats, by first identifying the average annual recharge for these aquifers and then using other suitable methods recommended in the proposed NES;

(vi) Identifies which aquifers are linked to surface flow in rivers (e.g., the Waipaoa and Te Arai Rivers) and applies the minimum flow set for those rivers to any groundwater takes from the linked aquifers; and

(vii) Allows for a process to review the conditions of existing consents (under s128 of the RMA) to bring the current allocation 'on paper' into line with the volume of water that is actually needed and available according to the allocation limits identified in the regional plan.

6. References

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Appendix I: Copy of interim limits section from proposed NES (MfE 2008)

5 Proposal for an NES on Ecological Flows and Water Levels

The proposed national environmental standard is intended to complement and enhance the existing Resource Management Act process for establishing environmental flows and water levels through regional plans. The proposal has been developed in response to one of the challenges identified by regional councils.

The proposed national environmental standard will apply to all water bodies, but the effect of the standard on any individual water resource will vary according to existing regional plan provisions.

The proposal includes interim limits that will apply to all water bodies that are not covered by environmental flows and water levels established through a regional plan process. The proposal will also specify which methods are appropriate for determining the ecological component of environmental flows and water levels. These methods will be triggered when applications for resource consent that would breach the interim environmental flows and/or water levels are considered or when such an environmental flows and/or water levels are reviewed, added to or changed in a regional plan. The methods will ensure that the process is transparent and consistently applied.

5.1 Proposed interim limits

The proposed national environmental standard establishes interim limits on alterations to flows and water levels that will apply to water bodies for which there are no environmental flows or water levels specified in a proposed or operative water plan. The interim limits will apply until an alternative is established through the regional plan process.

The interim limits on alterations to flows and water levels all clearly establish a limit to the amount of available water.

An interim limit to alteration of water levels for lakes has not been included. Natural lakes, as opposed to controlled or artificial lakes, are not a major source of water for taking and diversion. A common (or standardised) measure of lake size and relative level variation is not available.

The proposed national environmental standard establishes interim limits on alterations to flows and water levels derived from expert scientist and regional council staff experience with many existing environmental flows and water levels. The interim flows and water levels are also intended to accommodate other values, such as recreational, natural character, and cultural flows. While there is some differentiation between river size and groundwater type, the interim limits are generalised across very different water-body types, so they are set at a level that caters for most water bodies. Water bodies were not further differentiated because these interim limits are intended to be in place only until a regional council has the time and resources to develop its own default or catchment-specific limits. At that stage, local knowledge and expertise can address and respond to differences among rivers and systems.

5.1.1 Proposed interim limits for groundwater

For shallow, coastal aquifers (predominantly sand)

An allocation limit of, whichever is the greater of:

- 15% of the average annual recharge as calculated by the regional council
- the total allocation from the groundwater resource on the date that the standard comes into force less any resource consents surrendered, lapsed, cancelled or not replaced.

For all other aquifers

An allocation limit of, whichever is the greater of:

- 35% of the average annual recharge as calculated by the regional council
- the total allocation from the groundwater resource on the date that the standard comes into force less any resource consents surrendered, lapsed, cancelled or not replaced.

For groundwater that is shown to be connected to adjacent surface water, the environmental flow or water level set for the surface water body will also apply to the management of groundwater takes.

5.1.2 Proposed interim limits for wetlands

Wetlands are ecosystems that have been identified nationally[12] as a national priority for biodiversity because they are greatly diminished in extent and considered rare and threatened ecosystems. Wetlands are not a major source of water for consumptive use, but even small changes in the amounts of water can affect their ecosystem values. A very conservative approach has been used for wetlands. The interim limit essentially prevents any increase in the abstraction of water from a wetland unless provision is made in a regional plan.

For all wetlands

- No change in water levels, beyond the water level variation that has already been provided for by existing resource consents on the date the Standard comes into force.

5.1.3 Proposed interim limits for rivers and streams

To meet the requirements to clearly establish a limit on the available water, the interim flows for rivers and streams specify:

- a minimum flow – a flow at which the abstraction of water ceases

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[12] http://www.mfe.govt.nz/issues/biodiversity/initiatives/private-land/work-programme.html#national 15 February 2008.

- an allocation limit – a limit on the amount of water that can be abstracted from the resource that will ensure that flow variability is maintained and the river is not held at its minimum flow for excessive periods of time.

If an existing environmental flow in a plan meets one requirement but not the other, then the interim provisions shall apply to the requirement not addressed by the plan.

For rivers and streams with mean flows less than or equal to 5 m^3/s

A minimum flow of 90% of the mean annual low flow (MALF) as calculated by the regional council and an allocation limit of, whichever is the greater of:

- 30% of MALF as calculated by the regional council
- the total allocation from the catchment on the date that the national environmental standard comes into force less any resource consents surrendered, lapsed, cancelled or not replaced.

For rivers and streams with mean flows greater than 5 m^3/s

A minimum flow of 80% of MALF as calculated by the regional council and an allocation limit of, whichever is the greater of:

- 50% of MALF as calculated by the regional council
- the total allocation from the catchment on the date that the Standard comes into force less any resource consents surrendered, lapsed, cancelled or not replaced.

Question 3 – The need for interim limits

Do you support the need for, and introduction of, interim limits set through a national environmental standard?

Question 4 – The interim limits

Do you have comments on the numbers for the interim flows and water levels? Are there sufficient divisions of rivers and streams and groundwater systems?

Question 5 – Time bound

The proposal does not set a time limit for how long the interim limits will apply. There is some concern that this will not encourage catchment-specific or regional default flows to be set. Do you think the interim flow and water levels should apply for only a limited period?

Appendix II: Copy of extracts from Beca (2008) (In MfE 2008)

Appendix 4: Executive Summary and Recommendations from: *Draft Guidelines for the Selection of Methods to Determine Ecological Flows and Water Levels* (Beca 2008)

Introduction

The Ministry for the Environment (MfE) is assessing the need for a National Environmental Standard (NES) on methods for establishing ecological flows and water levels for rivers, lakes, wetlands, and groundwater resources. As a part of this process, MfE sought scientific guidelines for selecting appropriate methods for determining ecological flows and water levels. Beca Infrastructure Ltd (Beca) was commissioned to coordinate the 'capture' of this advice from some of New Zealand's top experts on the science of assessing the ecological requirements for ecological flows and water levels. This executive summary documents which approach the expert group recommends to be taken in selecting an appropriate method. The full report provides the underlying logic behind the recommendations.

It should be noted that this report relates only to method selection for establishing ecological flow requirements. **Ecological** flows are defined here as "the flows and water levels required in a waterbody to provide for the ecological integrity of the flora and fauna present within waterbodies and their margins". This report offers no guidance on the process of how to set **environmental** flows (defined as "the flows and water levels required in a waterbody to provide for a given set of values which are established through a regional plan or other statutory process") or the management implications of environmental flow decisions.

Methodology

Beca facilitated a two-day workshop in Christchurch on 19–20 December 2006. The workshop participants:

(i) listed the ecological management objectives/values relating to the ecological flow/level of the river, lake, wetland or groundwater resource being considered, together with factors that might affect the ability to achieve that objective

(ii) listed the technical methods applicable to the setting of ecological flows and water levels for the type of water body under consideration and debated the pros and cons of each method

(iii) developed a matrix of methods applicable depending on the significance of the values perceived for the water resource under consideration, and the degree of hydrological alteration being considered for that water resource.

Subsequent to the workshop, lead writers – for each of: rivers, lakes and wetlands, and groundwaters – drafted documents intended to support the recommendations. Each of these documents was reviewed by three members of the workshop team as well as by the Department of Conservation (in the case of rivers and lakes) before being consolidated by Beca.

Recommendations: rivers

It is proposed that the approach to selecting technical methods to determine the ecosystem flow requirements of rivers be based initially on the risk of deleterious effects on instream habitat according to the species present and natural mean stream flow (Table 1). The risk of abstraction decreasing available habitat depends on stream size and the species present in the stream, with higher risks of deleterious effects in small streams than in larger streams and rivers.

Table A4.1: Assessment of risk of deleterious effects on instream habitat according to fish species present and natural mean stream flow (and generic application to other values/management objectives°)

Mean flow (m^3/s)	Inanga,* upland bully, Crans bully, banded kopopu*	Roundhead galaxias, flathead galaxias, lowland longjaw galaxias, redfin bully,* common bully*	Salmonid spawning and rearing, torrentfish,* bluegill bully*	Adult trout+
<0.25	High	High	High	High
<0.75	Moderate	High	High	High
<5.0	Low	Moderate	High	High
<15.0	Low	Low	Moderate	High
15–20	Low	Low	Low	Moderate
>20	Low	Low	Low	Low

* Access to and from the sea is necessary.

\+ Access to spawning and rearing areas is necessary.

° Actual degree of impact will depend on the degree of hydrological alteration whether or not the level of risk is high or low.

Note: The data in the column for 'Salmonid spawning and rearing, torrentfish, bluegill bully', may be generically applied to invertebrates and riverine bird feeding (eg, wading birds, blue duck, black fronted tern).

The extent to which abstraction affects the duration of low flows is a useful measure of the degree of hydrological alteration. A high degree of hydrological alteration is assumed to occur when abstraction increases the duration of low-flow conditions to 30 days or more, with moderate and low levels of hydrological alteration corresponding to increases of about 20 days and 10 days, respectively.

The degree of hydrological alteration for a river can be determined, first by determining the risk based on mean flow and species present (Table 1), then using Table 2 to determine how the total abstraction (in terms of mean annual low flow, MALF) affects the degree of hydrological alteration for the stream and its risk category and its baseflow characteristics. In Table 2, a high baseflow river is one where the low flows are relatively high compared to the mean flow, such as in rivers with frequent freshes, rivers with their sources in hilly or mountainous areas or rivers fed from lakes, or springs. A low baseflow river is one where the low flows are very much lower than the mean flow, such as occurs in rain-fed rivers in areas that are not subject to orographic rainfall. Further details are given in the supporting document.

Table A4.2: Relationship between degree of hydrological alteration and total abstraction expressed as % of mean annual low flow for various risk classifications (Table A4.1) based on stream size and species composition

Risk of deleterious effect						Degree* of hydrological alteration
Low risk and high baseflow	Low risk and low baseflow	Moderate risk and high baseflow	Moderate risk and low baseflow	High risk and high baseflow	High risk and low baseflow	
<20%	<15%	<15%	<10%	<15%	<10%	Low
20–40%	15–30%	15–30%	10–25%	15–30%	10–20%	Medium
>40%	>30%	>30%	>25%	> 30%	>20%	High

* Abstraction of more than 40% of MALF, or any flow alteration using impoundments would be considered a high degree of hydrological alteration, irrespective of region or source of flow.

Once the degree of hydrological alteration is determined, Table 3 lists the technical methods that should be used to assess ecological flow requirements. One or more of the methods listed within each cell of Table 3 should be used to assess ecological flow requirements for the given combination of degrees of hydrological alteration and significance of instream values. In situations with high instream values, two or more methods from each cell should be used, because the risks to stream ecology of making an incorrect ecological flow decision are greater. The methods within each cell are not listed in hierarchical order and the choice of method(s) depends upon the perceived ecological problem affected by the flow regime. Specific recommendations of the use of each of the methods are given in the supporting document.

Hydrological alteration of rivers involves an examination of a number of hydrological statistics, including flow variability of the system, which affects the quality of instream habitat, and the connectivity of rivers with riparian wetlands, springs and groundwater. Potential critical factors include magnitude and duration of low flows or levels, timing, frequency and magnitude of floods and the inundation (as referenced to water level) of wetlands, surface–groundwater exchange, and maintenance of fish passage. This requires knowledge of the pattern and ecological significance of water level variation in wetland and groundwater systems.

Table A4.3: Methods used in the assessment of ecological flow requirements for degrees of hydrological alteration and significance of instream values

Degree of hydrological alteration	Significance of instream values		
	Low	**Medium**	**High**
Low	Historical flow method Expert panel	Historical flow method Expert panel	Generalised habitat models 1D hydraulic habitat model Connectivity/fish passage Flow duration analysis
Medium	Historical flow method Expert panel Generalised habitat models	Generalised habitat models 1D hydraulic habitat model Connectivity/fish passage	1D hydraulic habitat model 2D hydraulic habitat model Dissolved oxygen model Temperature models Suspended sediment Fish bioenergetics model Groundwater model Seston flux Connectivity/fish passage Flow variability analysis
High	Generalised habitat models 1D hydraulic habitat model Connectivity/fish passage Periphyton biomass model	Entrainment model 1D hydraulic habitat model 2D hydraulic habitat model Bank stability Dissolved oxygen model Temperature models Suspended sediment Fish bioenergetics model Inundation modelling Groundwater model Seston flux Connectivity/fish passage Periphyton biomass model	Entrainment model 1D hydraulic habitat model 2D hydraulic habitat model Bank stability Dissolved oxygen model Temperature models Suspended sediment Fish bioenergetics model Inundation modelling Groundwater model Seston flux Connectivity/fish passage Periphyton biomass model Flow variability analysis

NIWA Taihoro Nukurangi

Recommendations: lakes and wetlands

Lakes

The distribution and occurrence of healthy lake littoral habitats and communities vary with lake size, depth and water clarity. The risk of changing lake levels decreasing available habitat or adversely affecting communities depends on the lake bed profile (bathymetry), substrate type, water clarity, wave action as well as size and depth. The risks of deleterious effects are greater in shallower systems than in deep water bodies. Within a lake level range, impacts arise from changing seasonality in levels and the proportion of time spent at different levels (level duration).

It is proposed that for lakes, the risks for a potential change to lake level may be defined as follows:

- **Low**. Less than 0.5 m change to median lake level in lakes greater than 10 m depth, and less than 10% change in annual lake level fluctuation in lakes greater than 10 m depth; and less than 10% change in median lake level and annual lake level fluctuation in lakes less than 10 m depth; and, patterns of lake level seasonality (relative summer vs winter levels) remain unchanged from the natural state.
- **Medium**. Between 0.5 and 1.5 m change to median lake level and less than 20% change in annual lake level fluctuation in lakes greater than 10 m depth; and between 10 and 20% change in median lake level and annual lake level fluctuation in lakes less than 10 m depth; and, patterns of lake level seasonality (relative summer vs winter levels) show a reverse from the natural state.
- **High**. Greater than 1.5 m change to median lake level, and greater than 20% change in annual lake level fluctuation in lakes greater than 10 m depth, and more than 20% change in median lake level and annual lake level fluctuation in lakes less than 10 m depth; and, patterns of lake level seasonality (relative summer vs winter levels) show a reverse from the natural state.

The risks for a potential change to lake level must also be defined in relation to seasonal and inter-annual level variability as determined by the methods shown in Table 4 below and documented in full in the main report.

Once the risk of potential change to lake level has been established (degree of hydrological alteration) the technical methods that should be used to assess level requirements should be selected from Table 4. One or more of the methods listed within each cell of Table 4 should be used to assess ecological flow and level requirements for the given combination of degrees of hydrological alteration and significance of instream values. In situations with high lake values, two or more methods from each cell should be used, because the risks to ecology of making an incorrect ecological flow decision are greater. The methods within each cell are not listed in hierarchical order and the choice of method(s) depends upon the perceived ecological problem affected by the flow regime. Specific recommendations of the use of each of the methods are given in the supporting document.

The proposed categorisation of risks associated with potential changes in lake levels are based on the professional judgement/experience of lake experts within this team. We recommend that work be commissioned to provide scientific justification for this categorisation and provide an equivalent of MALF (and other flow statistics) based on level duration curves. Profiles of level duration demonstrate graphically and quantitatively the lake level regime, however there is currently no easy way to use these in a general rule-based format as they are calculated from absolute altitude. It will be possible to convert these to a relative level based on variance from a mean (or median) lake level. In this way curves between lakes could be compared and a general set of rules on level duration derived.

Table A4.4: Methods used in the assessment of ecological flow and water level requirements for degrees of hydrological alteration and significance of lake values

Degree of hydrological alteration	Lakes: Significance of values		
	Low	**Medium**	**High**
Low	Historical time series analysis Expert panel	Historical time series analysis Expert panel	Habitat analysis in drawdown zone Water balance models Species-environment models Residence time vs water quality modelling
Medium	Historical time series analysis Expert panel	Habitat analysis in drawdown zone Water balance models Species-environment models Residence time vs water quality modelling	Bank stability and geomorphology analysis Wave action assessment Water level and ramping rates Water clarity assessments Temperature modelling Processes-based water quality models Groundwater/surface water interaction
High	Habitat analysis in drawdown zone Water balance models Species-environment models Residence time vs water quality modelling	Bank stability and geomorphology analysis Wave action assessment Water level and ramping rates Water clarity assessments Temperature modelling Processes-based water quality models Groundwater/surface water interaction	Bank stability and geomorphology analysis Wave action assessment Water level and ramping rates Water clarity assessments Temperature modelling Processes-based water quality models Groundwater/surface water interaction Hydrodynamic water quality models

Wetlands

The distribution and occurrence of healthy wetlands varies with size and depth and connectivity to other hydrological systems. The risk of changing wetland levels decreasing available habitat or adversely affecting communities depends on the depth and the bathymetry and the dominant species present. Wetlands are generally shallow with wide littoral ephemeral areas that are dependent on a number of different flow-dependent variables. Therefore risks to wetlands are perhaps greatest compared with any other freshwater ecosystem. The risks of deleterious effects are greater in shallower than in deepwater wetlands, and wetlands without permanent connections to freshwater sources. The effect of changing inflows and/or outflows and therefore changing levels depends not only on the magnitude of change but also the timing, periodicity (hydroperiod) and duration of the levels.

It is proposed that for wetlands the potential risk of ecological change associated with changes in levels may be defined as follows:

- **Low**. Less than 0.2 m change in median water level; and, patterns of water level seasonality (summer vs. winter levels) remain unchanged from the natural state (summer relative to winter).
- **Medium**. Greater than 0.2 m and less than 0.3 m change to median water level; and, patterns of water level seasonality show a reverse from the natural state (summer relative to winter).
- **High**. Greater than 0.3 m change to median water level; and, patterns of water level seasonality show a reverse from the natural state (summer relative to winter).

The risks for a potential change to wetland level must also be defined in relation to seasonal and inter-annual variability in hydroperiod as determined by the methods shown in Table 5 below and documented in full in the main report.

Once the risk of potential change to wetland level has been established (degree of hydrological alteration) the technical methods that should be used to assess level requirements should be selected from Table 5. One or more of the methods listed within each cell of Table 5 should be used to assess ecological flow and level requirements for the given combination of degrees of hydrological alteration and significance of wetland values. In situations with high wetland value, two or more methods from each cell should be used, because the risks to ecology of making an incorrect ecological flow decision are greater. The methods within each cell are not listed in hierarchical order and the choice of method(s) depends upon the perceived ecological problem affected by the flow regime. Specific recommendations of the use of each of the methods are given in the supporting document.

Table A4.5: Methods used in the assessment of ecological flow and water level requirements for degrees of hydrological alteration and significance of wetland values

Degree of hydrological alteration	Wetlands: Significance of values		
	Low	Medium	High
Low (< 20 cm change)	Historical water level records Expert panel Remote delineation of site and catchment Wetland record sheet (MfE methodology)	Historical water level records Expert panel Remote delineation of site and catchment Wetland record sheet (MfE methodology)	Detailed local delineation Wetland hydrological condition assessment and model change (MfE methodology) Species-environment models Habitat assessment Water quality modelling
Medium (20–30 cm change)	Historical water level records Expert panel Remote delineation of site and catchment Wetland record sheet (MfE methodology)	Detailed local delineation Wetland hydrological condition assessment and model change (MfE methodology) Species-environment models Habitat assessment Water quality modelling	Full ecohydrological assessment Groundwater /surface water interaction Process-based water quality models Microtopographic survey
High (> 30 cm change)	Detailed local delineation Wetland hydrological condition assessment and model change (MfE methodology) Species-environment models Habitat assessment Water quality modelling	Full ecohydrological assessment Groundwater /surface water interaction Process-based water quality models Microtopographic survey	Full ecohydrological assessment Groundwater /surface water interaction Process-based water quality models Microtopographic survey

Recommendations: groundwater

Typically, knowledge of groundwater systems is less certain than knowledge of surface waters. Therefore, the approach for groundwater differs slightly from the approach for rivers, lakes and wetlands. A 'cumulative approach' to groundwater methods application is used in response to uncertainty and the unknowns associated with groundwater systems. A 'cumulative approach' to methods application follows the typical groundwater investigation process whereby simple models are used to build more complex models.

It is proposed that for groundwaters the potential risk for changes in levels may be defined as follows:

- **Low**: Less than 10% of average annual recharge
- **Medium**: 11% to 25% of average annual recharge
- **High**: Greater than 26% of average annual recharge.

Once the risk of potential change to groundwater levels has been established (degree of hydrological alteration) the technical methods that should be used to assess level requirements should be selected from Table 6. One or more of the methods listed within each cell of Table 6 should be used to assess ecological flow requirements for the given combination of degrees of hydrological alteration and significance of the resource values. The methods within each cell are not listed in hierarchical order and the choice of method(s) depends upon the perceived ecological problem affected by the flow regime. Specific recommendations of the use of each of the methods are given in Chapter 4.

Potential changes to flow regimes relate to the percentage allocation of aquifer recharge. It is acknowledged that these allocation thresholds from low to high may vary depending on the nature of the groundwater system. However the recharge percentages as presented, provide a conservative approach to groundwater allocation in most circumstances. 'Significance of values' should be used as the main criterion for determining methods most suitable for water level requirements when the relationship between groundwater allocation and the potential change to the flow regime is uncertain (eg, in deep confined aquifer systems where recharge and discharge are not well defined.

Table A4.6: Methods used in the assessment of water level requirements for degrees of hydrological alteration and significance of groundwater values

Potential degree of hydrological alteration from groundwater allocation	Groundwater: Resource values and their relative significance		
	Low (not sensitive)	Medium	High (extremely sensitive)
Low (up to 10% of recharge)	Conceptual model / simple water balance Historical levels	Conceptual model / simple water balance Historical levels Expert panel Detailed water balance	Detailed water balance Time series analysis Analytical models Numerical quantity models – steady state Numerical quantity models – transient Numerical quality models – transport
Medium (11–25% of recharge)	Conceptual model / simple water balance Historical levels Expert panel	Detailed water balance Time series analysis Analytical models Numerical quantity models – steady state	Numerical quantity models – steady state Numerical quantity models – transient Numerical quality models – transport Consolidation models
High (over 25% of recharge)	Detailed water balance Time series analysis Analytical models Numerical quantity models – steady state Numerical quantity models – transient Numerical quality models – transport	Numerical quantity models – steady state Numerical quantity models – transient Numerical quality models – transport Consolidation models	Numerical quantity models – steady state Numerical quantity models – transient Numerical quality models – transport Consolidation models

Appendix III: Fish recorded in the NZFFD for the Waipaoa catchment

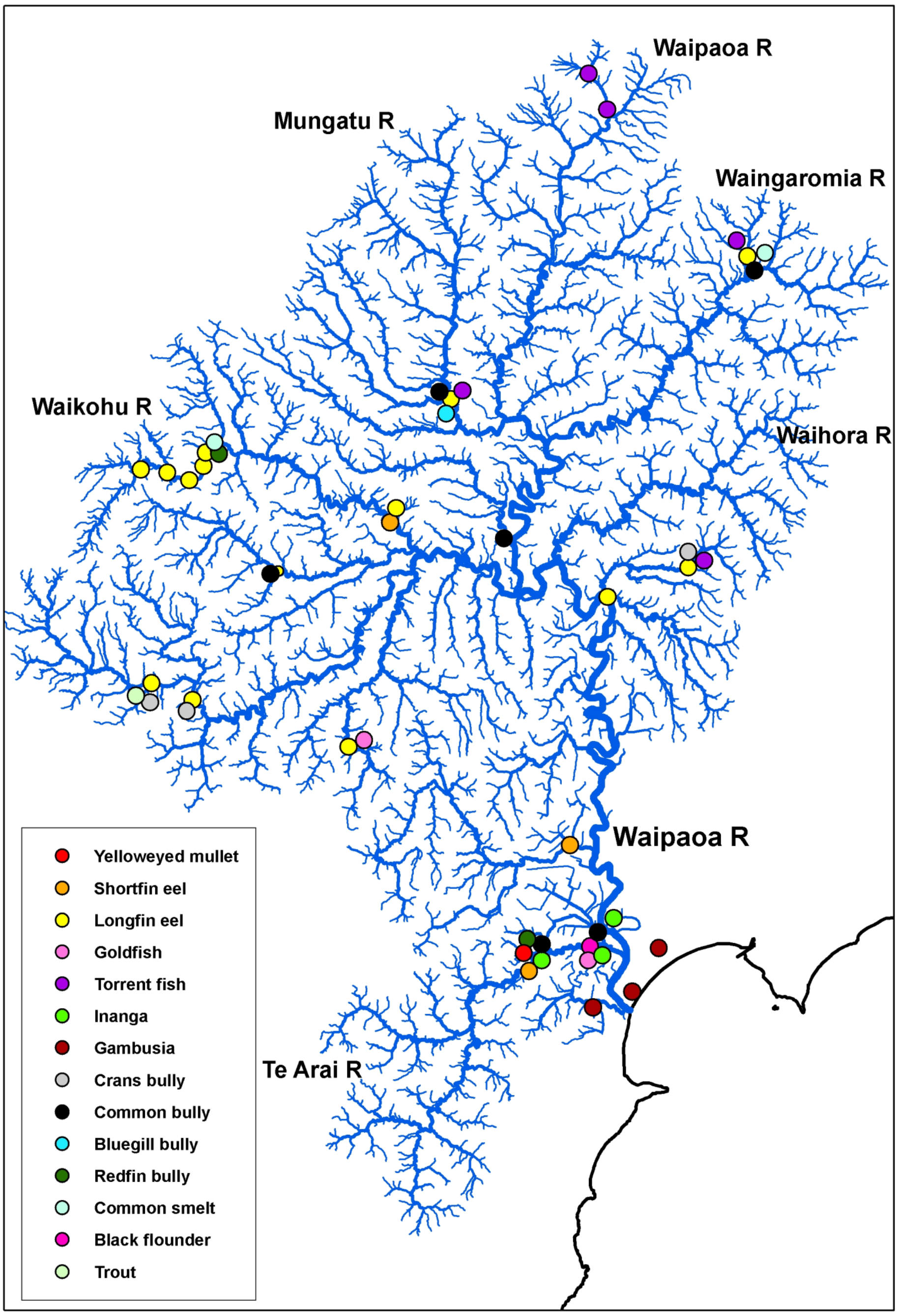

Figure AIII – 1: Fish species present in the Waipaoa catchment, as recorded in the NZFFD as at May 2009.

Table AIII – 1:

site	nzms	east	north	common name	scientific name
Te Arai River	y18	2937100	6269100	black flounder	Rhombosolea retiaria
Mangapapa Stream	x17	2928200	6304200	bluegill bully	Gobiomorphus hubbsi
Te Arai River	y18	2937100	6269100	bully species	Gobiomorphus spp
Whatatuna Stream	y18	2937600	6270000	common bully	Gobiomorphus cotidianus
Mangapapa Stream	x17	2928200	6304200	common bully	Gobiomorphus cotidianus
Wheao Stream	y17	2931600	6295200	common bully	Gobiomorphus cotidianus
Waihuka River	x17	2917100	6293100	common bully	Gobiomorphus cotidianus
Tarekepokia Stream	y16	2947300	6313600	common bully	Gobiomorphus cotidianus
Te Arai River	y18	2934000	6268200	common bully	Gobiomorphus cotidianus
Whakaahu Stream	y18	2935800	6275600	common bully	Gobiomorphus cotidianus
Tarekepokia Stream	y16	2947300	6313600	common smelt	Retropinna retropinna
Waikohu River	x17	2913100	6301000	common smelt	Retropinna retropinna
Wharekopae River	x17	2911600	6284900	crans bully	Gobiomorphus basalis
Wharekopae River	x17	2909000	6286000	crans bully	Gobiomorphus basalis
Mangaoai Stream	y17	2943400	6293400	crans bully	Gobiomorphus basalis
Te Arai River	y18	2937100	6269100	eel species	Anguilla spp
Whatatuna Stream	y18	2937600	6270000	eel species	Anguilla spp
Wheao Stream	y17	2931600	6295200	eel species	Anguilla spp
Waihuka River	x17	2917100	6293100	eel species	Anguilla spp
Mangaoai Stream	y17	2943400	6293400	eel species	Anguilla spp
Tarekepokia Stream	y16	2947300	6313600	eel species	Anguilla spp
Waimatau Stream	y16	2936900	6325200	eel species	Anguilla spp
Waipaoa River	y16	2938300	6322100	eel species	Anguilla spp
Karaua Stream tributar	y18	2937300	6265200	gambusia	Gambusia affinis
Awapuni Creek tributar	y18	2939800	6266200	gambusia	Gambusia affinis
Whakaahu Stream tribut	y18	2935800	6275700	gambusia	Gambusia affinis
Awapuni Creek	y18	2941500	6269000	gambusia	Gambusia affinis
Te Arai River	y18	2937100	6269100	goldfish	Crassius auratus
Unnamed pond	x17	2921600	6281900	goldfish	Crassius auratus
Te Arai River	y18	2937100	6269100	inanga	Galaxias maculatus
Whatatuna Stream	y18	2937600	6270000	inanga	Galaxias maculatus
Te Arai River	y18	2934000	6268200	inanga	Galaxias maculatus

site	nzms	east	north	common name	scientific name
Whakaahu Stream	y18	2935800	6275600	inanga	Galaxias maculatus
Wharekopae River	x17	2911600	6284900	longfin eel	Anguilla dieffenbachii
Waikohu River	x17	2924300	6296300	longfin eel	Anguilla dieffenbachii
Wharekopae River	x17	2909000	6286000	longfin eel	Anguilla dieffenbachii
Unnamed pond	x17	2921600	6281900	longfin eel	Anguilla dieffenbachii
Mangapapa Stream	x17	2928200	6304200	longfin eel	Anguilla dieffenbachii
Waihuka River	x17	2917100	6293100	longfin eel	Anguilla dieffenbachii
Mangaoai Stream	y17	2943400	6293400	longfin eel	Anguilla dieffenbachii
Tarekepokia Stream	y16	2947300	6313600	longfin eel	Anguilla dieffenbachii
Mangaoai Stream	y17	2938000	6292200	longfin eel	Anguilla dieffenbachii
Whakaahu Stream	y18	2935800	6275600	longfin eel	Anguilla dieffenbachii
Waikohu River	x17	2908300	6299700	longfin eel	Anguilla dieffenbachii
Waikohu River	x17	2910000	6299500	longfin eel	Anguilla dieffenbachii
Waikohu River	x17	2911400	6299000	longfin eel	Anguilla dieffenbachii
Waikohu River	x17	2912300	6299900	longfin eel	Anguilla dieffenbachii
Waikohu River	x17	2912700	6300800	longfin eel	Anguilla dieffenbachii
Waikohu River	x17	2913100	6301000	longfin eel	Anguilla dieffenbachii
Te Arai River	y18	2937100	6269100	mullet species	Mugil spp
Te Arai River	y18	2934000	6268200	redfin bully	Gobiomorphus huttoni
Waikohu River	x17	2913100	6301000	redfin bully	Gobiomorphus huttoni
Waikohu River	x17	2924300	6296300	shortfin eel	Anguilla australis
Te Arai River	y18	2934000	6268200	shortfin eel	Anguilla australis
Whakaahu Stream	y18	2935800	6275600	shortfin eel	Anguilla australis
Mangapapa Stream	x17	2928200	6304200	torrent fish	Cheimarrichthys fosteri
Mangaoai Stream	y17	2943400	6293400	torrent fish	Cheimarrichthys fosteri
Tarekepokia Stream	y16	2947300	6313600	torrent fish	Cheimarrichthys fosteri
Waimatau Stream	y16	2936900	6325200	torrent fish	Cheimarrichthys fosteri
Waipaoa River	y16	2938300	6322100	torrent fish	Cheimarrichthys fosteri
Wharekopae River	x17	2909000	6286000	trout species	Salmonid spp
Te Arai River	y18	2934000	6268200	yelloweyed mullet	Aldrichetta forsteri