NIWA
Taihoro Nukurangi

Accounting for dams in evaluating total allocation

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Executive summary

Northland Regional Council (NRC) commissioned NIWA to provide advice regarding the most appropriate methods for accounting for dam takes in calculating total allocated volumes in Northland.

In managing water allocation in a catchment, there are two primary flow thresholds that need to be considered, the management flow and the minimum flow. The management flow is when insufficient water remains in the river to fully satisfy the total allocated volume and allocation must therefore be restricted. The minimum flow is when all remaining water is allocated to instream values and thus all takes should be stopped. The management flow is the sum of the minimum flow and total allocated volume. Determination of the total allocated volume is therefore necessary for calculating the management flow. Councils are also required to set total allocation limits for water bodies in accordance with the National Policy Statement for Freshwater Management.

NRC’s current approach to incorporating dam takes in calculations of total allocation for a catchment is to treat them in the same way as all other surface water takes. That is to assume the worst case scenario whereby all users take the full volume of water they are consented to take. With respect to dam takes this means assuming that as long as the inflow is equal to or greater than the sum of the minimum flow and the maximum consented take combined, that all water taken will be ‘run-of-river’ water and no water would be taken from storage. Total allocated volume is therefore the sum of the maximum volume of all consented surface water takes.

It is considered that this is an appropriate protocol for evaluating the contribution of dam takes to total allocated volume in the absence of more detailed data on dam operations. However, in some circumstances, this approach will underestimate the total effective take volume as it fails to account for storage recharge.

Stored water offers the opportunity to manipulate the burden of water restrictions between users. However, the existing first come first served allocation regime in Northland, in combination with a lack of easily enforceable rules and limits, restricts the scope to take advantage of this.

1 Introduction

1.1 Background

Northland Regional Council (NRC) commissioned NIWA to provide advice regarding the most appropriate methods for accounting for dam takes in calculating total allocated volumes in Northland. The work was carried out under an Envirolink Small Advice Grant (1021-NLRC136) from the Ministry of Science and Innovation. This advice is part of NRC's continuing programme to develop a robust, defensible and affordable framework for sustainably managing water allocation in Northland.

1.2 Approach

- Attend brainstorming session with NRC water allocation staff to consider the effects and consequences of instream dam takes and how best to account for them in calculating total allocation and establishing sustainable allocation limits.
- Collate information and outline options for NRC to ensure consistent and clear management of dam takes when calculating total allocation and sustainable allocation limits for catchments.

1.3 Scope

The focus of this report is to summarise the issues discussed at the meeting with NRC staff on 27 September 2011 and to advise on the appropriateness of NRC's protocols for managing dam takes in its calculations of total catchment allocation.

The report is not intended to address issues relating to the potential environmental impacts of dams such as barriers to fish migration, changes in water quality and water temperature, changes in sediment supply, changes in the frequency and timing of flushing flows or the physical impacts of dam construction. The report is also not intended to address the potential benefits of dams such as opportunities for increased crop production or economic growth.

For the purposes of this report "dam" refers to an instream impoundment designed to allow manipulation of river discharge for water storage. The report does not address issues relating to off-line storages. It also does not deal with the effects of storage recharge on the availability of water.

The scope and funding limitations mean that this study has been constrained to a high level summary evaluation of NRC's current approach to dealing with dam takes. The effect of dam takes on allocation management is highly complex and case specific, meaning that there is no catch-all approach to evaluating their effects. Ideally the hydrological consequences of dams should be evaluated through time-series models that calculate dam outflows by taking account of dam operations, dam capacity and inflows on a case-by-case basis.

2 The significance of dam takes

The reliability of freshwater supply is an important determinant of the efficiency and effectiveness of water use. Where water resources are naturally unreliable, or demand for water resources is high, water storage provides the opportunity to increase supplies and their reliability.

Water storage is typically achieved through the construction of dams to capture run-off or impound rivers. Dams are designed to capture water and manipulate the magnitude, frequency and timing of downstream flows. Regulation and stabilization of the flow regime can provide greater certainty for water resource users, supporting investment decisions and potentially enhancing economic growth.

In Northland, water storage has been promoted as a way of supporting economic development in the region. There are many small dams in the region associated with the development of horticulture, dairying and for stock drinking. Larger dams also exist for public water supply, reticulated horticultural supplies and hydro-electric power generation.

There is now widespread recognition that dams can impair river ecosystems through disruption of natural hydrological, geomorphological, physico-chemical and ecological structure and function (Petts 1984, Poff & Hart 2002). The type and magnitude of environmental alteration is a consequence of interactions between natural processes, dam characteristics and the dam operating regime. The large variation in dam and river attributes makes understanding and managing the ecological impacts of dams complex (Poff & Hart 2002).

Dams adversely impact the structure and function of river ecosystems both individually and cumulatively through a variety of mechanisms including disruption of downstream fluxes of water and sediment (Bunn & Arthington 2002), changes in water temperature and by creating barriers to migration (Williams 2008). This can disrupt the successful completion of species' life-histories, reduce available habitat, alter the structure of food webs and cause shifts in community composition including facilitation of invasion by non-native organisms (Lytle & Poff 2004).

Managing the role and contribution of dams to water allocation management is therefore critical for managing the status of aquatic ecosystems and other instream values.

3 Dam takes in allocation management

As stated in the NPS for Freshwater Management (MfE 2011), allocation limits should, as a minimum, consist of a minimum flow, i.e., the flow below which a river should not fall, and an allocation volume, i.e., the total amount of water that can be taken from the river. These limits should be set to protect freshwater values, allow calculation of reliability of supply and provide clarity for those applying for new takes. In order to efficiently manage water allocation in a catchment, it is necessary to understand how much water is taken relative to the allocation limits. Where limits are exceeded, management action may be required to avoid adverse effects on freshwater values and downstream reliability of supply.

The presence of dams in a catchment complicates the understanding of how much water is taken because dams can modify the magnitude, frequency and timing of river flows. Water captured by dams provides greater reliability of supply for a dam take, but can reduce the availability of water to downstream users. The effect of dams on downstream takes is dependent on factors such as dam size, storage capacity, operating regime, position in the catchment and antecedent weather conditions. Consequently, the precise impact of each individual dam on the allocation regime of a catchment can be unique. This means that integration of dam takes into the evaluation of total allocation in a catchment can be challenging. It is with regards to this process that NRC has approached NIWA for advice.

3.1 The existing approach in Northland

NRC's current approach to evaluating dam takes when calculating total allocation for a catchment is to treat them in the same way as all other surface water takes. This involves assuming the worst case scenario whereby all users continually take the full volume of water they are consented to take. Total allocation is therefore the sum of the maximum volume of all consented surface water takes. Where possible, this is then adjusted to account for the estimated additional volume of water taken under permitted activity status.

Permitted takes are allowed for under rules set out in the Regional Plan that entitle water users to take a small volume of water for essential uses e.g., stock drinking water, without the need for a consent. Users are encouraged to register these takes with the council, but have not as yet been required to do so. Consequently, knowledge of permitted water use is limited. For ease of explanation, this component of total allocation will be ignored for the remainder of this discussion, but was mentioned here to acknowledge its significance in some catchments.

The approach of summing total consented take volumes to evaluate the volume of surface water takes is common practice in the absence of data on the amount of water actually used. It is recognised that the disparity between total consented allocable volume and actual takes represents a potential inefficiency in the allocation regime. However, for the majority of water users, the time they are most likely to take the full consented volume is in dry, low flow conditions, which is also the time when water is likely to be in shortest supply. It is therefore appropriate to evaluate the potential worst case scenario.

3.2 Is there a problem with this approach?

Some NRC staff have questioned the validity of the existing approach to evaluating the contribution of dam takes to total allocation. In Northland, the total consented volume may be satisfied either through taking ‘run-of-river’ water and/or through drawdown of stored water. Users may not exceed the consented volume, even if additional water is available in storage. It is argued that, particularly under summer low flows, users will partially satisfy their total consented take volume by drawdown of storage, rather than by only taking ‘run-of-river’ water. Consequently, it is suggested that the evaluation of total allocation in a catchment is over-stated by inclusion of the full consented volume for dam takes.

In managing water allocation in a catchment, for a given allocation block there are two critical flow thresholds that need to be considered (Figure 3-1). Firstly, there is the flow that is equal to the total allocated volume (ΔQ) plus the minimum flow (Q_min). This can be termed the management flow and is the flow below which the total allocated volume can no longer be fully satisfied and therefore restrictions on use must be implemented (R_1). The second is the minimum flow (Q_min), the point at which all water remaining in the river is allocated to the protection of instream values and therefore all water takes for out of stream use must cease (R_2). Determination of the total allocated volume for a given allocation block is therefore critical to managing allocation in a catchment.

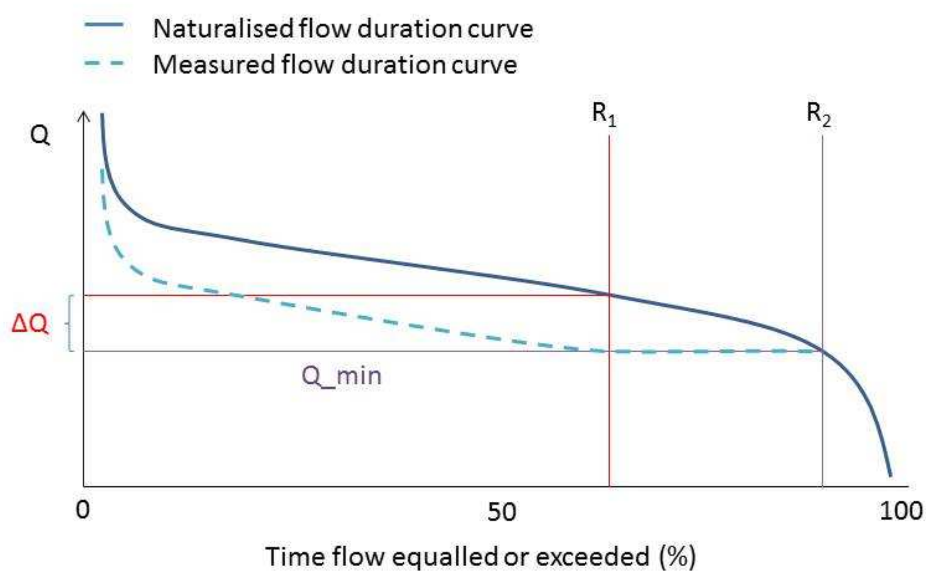

Figure 3-1: Idealised flow duration curve illustrating concept of management flow and reliability of supply.

As mentioned previously, when evaluating total allocation in a catchment, it is necessary and appropriate to take a precautionary approach that considers the worst case scenario involving all consented users utilising their full consented take. With respect to dam takes under the rules applied in Northland, it must therefore be assumed that (provided the minimum flow is released from the dam) as long as the inflow is equal to or greater than the sum of the minimum flow and the maximum consented take combined, that all water taken would be ‘run-of-river’ water and no water would be taken from storage, e.g., Figure 3-2A. This is reasonable behaviour to expect from dam take users as they seek to maximise the potential benefits of their investment in storage capacity. As inflows fall below the sum of the minimum flow and the maximum consented take, only then will dam take users begin to utilise water from storage to subsidise the shortfall in inflows (Figure 3-2B). This substitution of ‘run-of-river’ water for stored water will continue until the point at which inflows are equal to or less than the minimum flow, when all water taken will be from storage (Figure 3-2C).

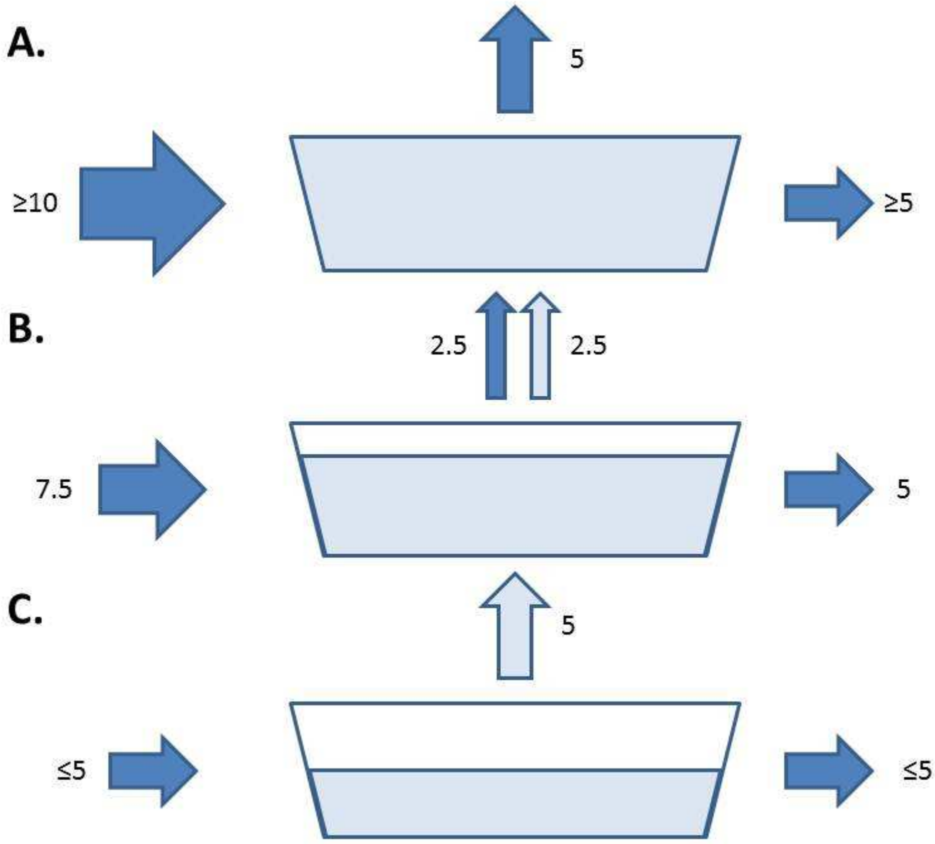

Figure 3-2: Conceptual model of dam take utilisation. Dark blue is run-of-river water. Light blue is storage.

Based on the assumptions illustrated above, it can be seen that NRC’s existing approach to evaluating the contribution of dam takes to the total allocated volume in a catchment is sensible if the aim is to identify the management flow for a river. All users are entitled to take their full consented allocation from the river if they choose to do so, and thus in determining management flows, it is necessary to base calculations on the maximum possible take from all users, including dam takes. Substitution of stored water for run-of-river water (Figure 3-2B & C) to satisfy a take in the way highlighted by some NRC staff does not therefore become relevant until flows fall below the management flow, at which point restrictions on use are required. Figure 3-2 illustrates how, for an individual dam take user, as flows fall below the management flow the effective take from a dam (the amount of ‘run-of-river’ water taken) is in essence self-regulating as the deficit in river flows is substituted by water from storage. However, the availability of stored water provides options for managing the burden of water restrictions by transferring it between users. The issue of managing water storage drawdown in periods of low water availability therefore becomes a value judgement that requires clear freshwater management objectives and associated limits, supported by strong rule structures in the regional plan and well defined and enforceable consent conditions for individual users.

A potentially more significant issue with the current approach to evaluating the magnitude of dam takes is dealing with storage recharge. In Northland, no limits are placed on the amount of water that a user can ‘take’ to recharge or fill storage when not at full capacity. This means that under some circumstances, the effective take of dam users may be greater than the consented volume. Figure 3-3 illustrates a situation whereby the user is taking their full consented volume of five units, but is also ‘taking’ an additional five units to refill their storage, meaning that they are in effect taking 10 units. Under this scenario, the approach taken by NRC for calculating total allocated volume will underestimate the total effective take in a catchment.

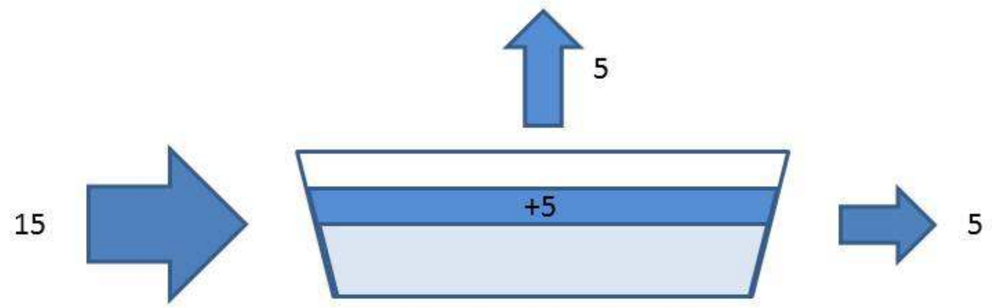

Figure 3-3: Illustration of the impact of storage recharge on effective take volume.

The impact of storage recharge on the availability and reliability of water to downstream users and instream values will vary depending on storage capacity and the magnitude, timing and duration of recharge. If total storage capacity is relatively low and recharge primarily occurs during periods of high water availability, e.g., winter, there may be negligible impact on downstream and instream water users. However, if storage capacity is relatively high and recharge takes place following a prolonged dry period, the duration of low flows may be significantly extended, with subsequent impacts on instream and other values.

4 Conclusion

- Given the absence of information about future dam operations, it is considered that NRC's existing approach to accounting for dam takes in evaluating total allocation in a catchment is appropriate for determining the catchment management flow and for supporting the determination of allocation limits. However, ideally the hydrological consequences of dams should be evaluated through time-series models that calculate dam outflows by taking account of dam operations, dam capacity and inflows. This is because each dam and set of operating rules can result in very different hydrological consequences.
- Storage recharge may increase the effective take of dam users, meaning that under some circumstances NRC's current approach to evaluating total allocation will underestimate the total take.
- When flows fall below the management flow, stored water offers the opportunity to manipulate the burden of water restrictions between users. However, the first come first served allocation regime limits the scope to take advantage of this.
- The efficient and equitable management of water allocation requires clear freshwater management objectives with associated targets, supported by well-defined and enforceable rules.

5 References

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