Review of groundwater information for the Poverty Bay Aquifers

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1. Introduction

This report provides outputs from a NIWA review of information regarding the Poverty Bay aquifers, carried out under Envirolink Small Advice Grant 835-GSDC74.

The aims of this work were to:

i) identify groundwater information available within Gisborne District Council (GDC); and

ii) review the current state of knowledge to develop an understanding of aquifer recharge.

Original plans to review GDC's own groundwater data were not able to be carried out for this report. Instead the review reported here is focussed on existing reference material on the Poverty Bay aquifer system. This work is intended as a progress step towards GDC's better understanding of the Poverty Bay aquifers, and in particular recharge processes.

The need for this work arose from recommendations in an earlier report prepared for GDC titled *Implications of the Proposed National Environmental Standard on Ecological Flows and Water Levels* (Norton 2009). In particular that report recommended 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." (Norton 2009).

2. Information review

An examination of the groundwater resources of the Poverty Bay flats in the Gisborne region was undertaken to identify the types of technical methods that the Gisborne District Council (GDC) could use for the management of the ecological flows and groundwater levels. The following sources were consulted:

- Barber 1993

- Beca 2008
- Gordon 2001
- Norton 2009
- MfE 2008
- Taylor 1994.

It must be noted that while some inconsistency may exist between the findings of these earlier studies and the existing hydrogeologic conditions in the Poverty Bay flats, these references continue to be an important source for credible groundwater data in the area. Much of the information presented in this report is based on the understanding of the aquifer systems according to these earlier interpretations of the data. New and/or updated interpretations will require additional information about the site (e.g., local and regional water levels, aquifer tests etc).

2.1. Overview of the aquifer system

The Poverty Bay flats are located in the coastal alluvial plain of the Waipaoa River in the North Island, and cover an area of 180 km^2. The hydrogeology of the flats comprises a five aquifer system with intervening silt layers (aquitards). The aquifers have been identified as follows:

1. Te Hapara Sand
2. Shallow Fluvial Deposits
3. Waipaoa Gravel Aquifer
4. Makauri Gravel Aquifer
5. Matokitoki Gravel Aquifer

The aquifer system behaves in a “leaky” manner and recharge is dominated by river-derived leakage. Groundwater quality is variable in the system with shallow aquifers (1, 2 and parts of 3) containing the best quality water – though not of sufficient quality for industrial or drinking water uses. Aquifers 2 to 4 have no direct outlet to the sea and consequently can have further diminished water quality with increasing depth, aquifer thickness and residence times.

2.2. Summary of allocation estimates

The Makauri Gravel Aquifer is the primary source of groundwater for the flats and has experienced an 85% increase in allocation since 1997 (Gordon 2001, Norton 2009). Currently, the aquifer supplies approximately 52% (31,524 m^3/day) of the total consented groundwater allocation (60,980 m^3/day) (Norton 2009).

2.3. Initial recharge estimates

The Waipaoa River has been identified as the main source of recharge for the Makauri Gravel Aquifer with flow losses from the river of 150 – 400 l/s (13,000 - 35,000 m^3/day or 4.7 – 12.7 million m^3/year) to the subsurface (Barber 1993). These estimates suggest that allocation from the Makauri Gravel Aquifer (11.5 million m^3/year, Norton 2009[1]) accounts for about 90% of the available river recharge and may possibly exceed river recharge during low flows by more than 200%.

In addition, we undertook a simple calculation of possible recharge for the whole aquifer system, using a simple soil moisture method (see Appendix 1 for assumptions). Using data from 1972 to 2009, the average annual recharge estimate was 37.8 million m^3/year. Again comparing this number (for the whole aquifer system) to the current allocation situation (in just the Makauri), allocation would be around 30% of recharge. Allocation for the whole aquifer (22.3 million m^3/year, Norton 2009) would account for 58% of the estimated annual recharge for the whole system.

2.4. Discussion

The above information review and simple recharge calculation has shown that current allocation may be somewhere in the range between 30% and 200% of potential recharge for the aquifer system.

As stated in Norton (2009), the overarching aim of the current work is to enable GDC to apply the interim limits from the Proposed National Environmental Standard on Ecological Flows and Water Levels (NES) (MfE 2008), if that document were to come into force. In addition the NES provides guidance on methods to use to investigate and develop groundwater allocation limits. In the companion guidelines to the NES,

[1] Note that a typographical error has been identified in the numbers reported in some parts of Norton (2009). In the Executive Summary (page ii) an allocation limit of 1.5 million m^3/year is suggested for the Makauri aquifer, this being the current total allocation in terms of existing resource consents (provided by GDC). This should read 11.5 million m^3/year, as is correctly noted in the main body of the report at section 3.2.1 (page 7). This error is repeated in section 3.2.2 (page 8) of Norton (2009).

provided by Beca (2008), tables are given to help determine what range of methods should be used. Using table 4.2 of the Beca guidelines (Beca 2008 p78), it is necessary to determine both resource values and their relative significance, and the potential degree of hydrologic alteration from groundwater allocation. Resource values are not considered further here. The above figures (section 2.3) show that the Makauri Gravel Aquifer system is likely to be classified as potentially having a "high" (>25% of recharge) degree of hydrological alteration from groundwater allocation, as is the Poverty Bay aquifer system when considered as a whole. While further refinement of the recharge estimates may refine this degree of hydrologic alteration, the current estimates clearly indicate the need to use more complex methods necessary to understand aquifers under relatively high usage.

3. Summary

In this report we have summarised the nature of GDC's groundwater resource information at a high level, and a preliminary coarse estimate has been provided for average annual recharge for the Poverty Bay aquifer system. The current degree of risk of hydrological alteration from groundwater allocation in both the Makauri aquifer and the system as a whole has been assessed.

The groundwater resources of the Poverty Bay flats are interconnected and must be managed accordingly. Considering the importance of river leakage to aquifer recharge, the complex nature of the aquifer system, the considerable alteration to water flow and quality that may result with increased abstractions, and the high degree of hydrologic alteration that current abstraction is likely to be having, it is recommended that the GDC uses the most comprehensive methods in the Beca guidelines (Beca 2008) for the assessment of groundwater flow and levels.

While the groundwater resources in the Gisborne region are currently not showing signs of stress according to monitoring data from a deep bore in the Makauri Aquifer (see Figure 16.6 in Gordon 2001), the lack of detailed understanding of the aquifer system means that it is unclear whether this resource is within sustainable allocation limits, or whether future climatic variations may reduce recharge processes such that groundwater levels begin to decline as they did in the 1990's (see Figure 3.2.4 in Barber 1993).

Below is a list of methods for the assessment of systems with a high degree of hydrological alteration from groundwater allocation (taken from Beca 2008) that could be used by GDC for the management of the Poverty Bay flats aquifer system:

- Detailed water balance

- Time series analysis
- Analytical models
- Conceptual model
- Numerical models calibrated to steady state and transient conditions
- Transport models.

A complete description of these methods is contained in Beca (2008).

We recommend that the first priority for GDC should be to develop a qualitative framework for its groundwater resources by bringing together the existing hydrologic and geologic information in the form of a conceptual model. The conceptual model will summarize the current understanding of the sources of water to the region and sinks of water from the region (water balance), the physical boundaries, and the distribution of hydraulic properties within the region. Additionally, the development of a conceptual model is critical to the subsequent development of a more quantitative representation of the subsurface hydrology, such as a numerical groundwater flow model as recommended in the Beca (2008) guidelines. Ultimately it is highly likely that such quantitative methods will be needed to effectively manage GDC's groundwater resources and set appropriate allocation limits for the aquifers. The following lists the steps in the development of a conceptual model (they can be considered as tasks):

- Compile existing geologic and hydrogeologic information in the region (e.g., soil maps, surficial geology maps, land use maps, surface water maps, boring data, pumping test data, stream flows, groundwater levels, precipitation records, existing literature etc).
- Quantify sources and sinks of water in the region (e.g., using analytical/empirical models to quantify evapotranspiration, soil moisture recharge, baseflow, river leakage etc).
- Delineate upper and lower boundaries of the aquifers and aquitards (e.g., using boring data) and map hydrostratigraphic units in the region.
- Map groundwater levels (i.e., potentiometric surfaces) for each aquifer unit; delineate groundwater flow directions and groundwater recharge and discharge areas; estimate vertical and horizontal hydraulic gradients.

- Develop a conceptual groundwater flow model that incorporates the integrated behaviour of groundwater and surface water in the region.

Once this conceptual model is developed, further steps can be taken to develop numerical models of the aquifer systems for establishing locally-specific groundwater allocation limits for use in a regional water plan in the long term.

4. Recommendations

We recommend that GDC:

1. Hold a two day workshop with NIWA and GDC staff to work through steps 1) to 7) in the decision pathway provided in Section 4.3.2 of the Beca guidelines (Beca 2008). This will include technical groundwater staff from both NIWA (Mandy Meriano) and GDC, as well as relevant GDC planning staff and NIWA resource management integrators Helen Rouse and Ned Norton. The workshop will consider:

   (i) Outputs from this Envirolink SAG project (GSDC74; Meriano et al. 2010).

   (ii) Identification of the groundwater system boundaries and stresses.

   (iii) Linkages between groundwater and surface water.

   (iv) Identification of the values or management objectives of the system.

   (v) Based on i) to iv) above, refine or confirm selection of potential methods recommended in section 3 of this report.

   (vi) Based on workshop discussion, identify existing information and new information requirements for these potential methods.

   (vii) Work with GDC to design action plan for applying methods.

2. Use any guidance from the workshop discussions and report to refine the task list for the development of a conceptual model given in section 3 of this report.

3. Begin work on the development of a conceptual model as outlined in section 3 of this report above.

Further Envirolink medium advice grants could be sought to complete recommendations 1 and 2. Stage 3 of this work could be carried out using the already secured MAF Community Irrigation Fund (CIF) funding.

5. References

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MfE (2008). Proposed National Environmental Standard on Ecological Flows and Water Levels. Ministry for the Environment Publication Number ME868, Wellington. 61 p.

Norton, N. (2009). Implications of the Proposed National Environmental Standard on Ecological Flows and Water Levels for the Gisborne District. NIWA Client Report CHC2009-120, prepared for Gisborne District Council, July 2009.

Taylor, C.B. (1994). Hydrology of the Poverty Bay flats aquifers, New Zealand: recharge mechanisms, evolution of the isotopic composition of dissolved inorganic carbon, and groundwater ages. *Journal of Hydrology 158*: 151-185.

Appendix 1

Assumptions used in soil moisture recharge estimate (section 2.3):

- VCSN data for one point centered on Poverty Bay flats area was used, with excess rainfall or soil drainage data (the part of rainfall that remains after a simple soil store is filled) to estimate groundwater recharge.

- Note that this results in about 290 mm of rainfall recharging to groundwater. The soil store used is 150 mm and might be much too thin, which would result in this estimate of recharge being too high.

- no river recharge is considered.

- no loss terms are considered (i.e. groundwater discharge to the surface or to the sea).

- assumed Poverty Bay flats area of 135 km^2.

- estimate is as bulk recharge assuming the whole Poverty Bay flats area as one system.

- estimate of 38.7 million m^3/year is an average over the years 1972 to 2009, with the minimum being 14 million m^3/year.