MANAGED AQUIFER RECHARGE IN POVERTY BAY

Houlbrooke C,[1] Bower R,[1] Sinclair B,[1]
[1]Golder Associates (NZ) Limited

ABSTRACT

The Gisborne District Council (GDC) has identified long term water availability in the Poverty Bay area as being a potentially limiting factor in future regional development. A substantial proportion of the water used for irrigation across the Poverty Bay Flats is derived from groundwater, with most of the abstraction being from the confined Makauri Aquifer. Reviews of groundwater levels in the Poverty Bay Flats area have identified declining groundwater pressure trends in this aquifer as an environmental and water supply reliability issue. These trends are linked to increasing groundwater abstraction for irrigation purposes. Current groundwater abstraction rates are however substantially less than the consented allocations.

The GDC is investigating water management options to stabilize and restore groundwater trends and improve future water supply reliability in the Poverty Bay area. One option under investigation is the use of Managed Aquifer Recharge (MAR) to replenish and sustain groundwater yields from aquifers beneath the Poverty Bay Flats. Golder Associates (NZ) Limited (Golder) was commissioned by GDC to undertake a pre-feasibility assessment for a MAR program.

The MAR pre-feasibility assessment carried out by Golder included an evaluation of the challenges and needs for Poverty Bay water management, source water options, direct injection and surface infiltration options and water quality management requirements. The pre-feasibility analysis indicated a groundwater replenishment scheme (GRS) focused on the Makauri Aquifer has the potential to:

- Stabilize and restore current downward trends in groundwater levels within the aquifer
- Restore groundwater pressures within the aquifer
- Enable the establishment of a sustainable yield from the aquifer that exceeds current usage

A full feasibility study has now been initiated by GDC, including construction of a pilot injection bore to be drilled into the Makauri Aquifer and an injection trial to be undertaken during 2015-2016. Pumping and flow control equipment together with monitoring systems are to be installed in the injection bore. Monitoring systems will also be installed in selected nearby bores to track aquifer pressure and water storage responses to the trial. Changes in groundwater quality in response to the injection program will also be monitored.

In summary, Managed Aquifer Recharge (MAR) has the potential to replenish and support sustainable groundwater yields from aquifers beneath the Poverty Bay Flats. The next step in establishing a GRS for Poverty Bay is the construction and testing of a pilot trial injection bore.

KEYWORDS

Managed Aquifer Recharge, MAR, water storage, groundwater, water supply, injection bore, Groundwater Replenishment Scheme (GRS)

1 INTRODUCTION

The Gisborne District Council (GDC) has identified long term water availability in the Poverty Bay area as being a potentially limiting factor in future regional development. Irrigation for horticultural purposes is one of the main uses of water across the Poverty Bay Flats. A substantial proportion of the water used for irrigation is derived from groundwater, with most of the abstraction being from the confined Makauri Aquifer. Reviews of groundwater levels in the Poverty Bay Flats area have identified declining groundwater pressure trends in this aquifer as an environmental and water supply reliability issue. These trends are linked to increasing groundwater abstraction for irrigation purposes.

The GDC is investigating water management options to stabilize and restore groundwater trends and improve future water supply reliability in the Poverty Bay area. One option under investigation is the use of Managed Aquifer Recharge (MAR), to replenish and sustain groundwater yields from aquifers beneath the Poverty Bay Flats. Golder Associates (NZ) Limited (Golder) was commissioned by GDC to undertake a pre-feasibility assessment for a MAR program.

The key outcomes of the Stage 1A (Golder 2014a) pre-feasibility assessment of the Poverty Bay MAR project, were:

- The Makauri Aquifer is prospective candidate for a MAR pilot project due to its relatively high usage, declining groundwater pressure trends, broad extent, good transmissivity and lateral connectivity.

- A combination of treated water that is potentially available outside the irrigation season and existing infrastructure (e.g., Gisborne water supply reservoirs and delivery systems) provides an opportunity to trial the first components of a successful groundwater replenishment scheme (GRS).

- A system of direct water injection through bores is a clear option for artificial replenishment of Makauri Aquifer groundwater and was recommended for further design and pilot testing.

Following further investigations and modelling during Stage 1B of the pre-feasibility assessment (Golder 2014b), it was concluded that MAR has the potential to replenish and support sustainable groundwater yields from the Makauri Aquifer beneath the Poverty Bay Flats. GDC are now seeking to proceed with a pilot injection trial to the Makauri Aquifer (the “Pilot Project”).

2 BACKGROUND

2.1 POVERTY BAY FUTURE WATER STORAGE NEEDS

The GDC, through guidance and input from the Freshwater Advisory Group (FwAG), has conducted a future water resource supply and demand study (GDC 2011). This study indicated that increasing water demand could be limited by declining or uncertain supplies. This limitation would potentially result in constrained economic growth and degraded environmental outcomes for the district.

Changing climate patterns are expected to lead to increased rainfall variability, including prolonged droughts and/or more frequent high intensity rain events. This expectation of increased rainfall variability makes proactive and longer-term planning a key element for water resource management in the region.

Ongoing gains in irrigation efficiencies assist in the conservation of surface and groundwater resources. Using increasing efficiency as a sole management approach has however been shown to limit further opportunity. This is particularly true when water resources are deemed to be over-allocated and declining, or when the opportunity to actively replenish supplies is deemed feasible and cost effective.

Improved management of water storage for the Poverty Bay Flats area will be needed in order to provide for increasing demand while at the same time improving environmental outcomes for the district. This improved management may be in the form of purpose-built surface storage or through improved management of groundwater resources, or a combination of both in an integrated water management system.

Some of the highest unit prices for irrigated land in New Zealand occur in the Gisborne area (Doak et al. 2004). Consequently, irrigated horticulture is expanding over land previously used for dry-land sheep farming or other pasture uses. The combined economic value of irrigation across the Poverty Bay Flats is in the order of $18 million annually (Golder 2014b).

2.2 POVERTY BAY GROUNDWATER REPLENISHMENT SCHEME

The potential for developing a GRS in the Poverty Bay area based on MAR is being investigated due to the current pressure on groundwater allocation. Under current abstraction rates, the Makauri Aquifer is experiencing a trend of declining water storage. This trend is occurring despite incomplete utilisation of water allocated under existing groundwater take consents. This groundwater allocation pressure, combined with likely tighter future limits on surface water abstraction and increasing water demand by existing users, could result in future water supply reliability issues.

The area has potential for further investment in high value productive activities, provided long term security of water supply is achieved. The area has limited options for surface water storage. Local catchments are characterised by highly erodible sediments, resulting in silt-laden rivers and geotechnical and siltation problems for dam storage. Therefore a GRS based on MAR presents a good option for water storage in the area.

A correctly operated GRS should have few environmental effects, provided the quality of the water injected or infiltrated to the aquifer is acceptable. The physical footprint of a GRS for the Makauri Aquifer is potentially small. However, if water source and treatment systems need to be developed, the footprint and effects would need to be evaluated for each recharge point on a case-by-case basis. In general the environmental and cultural effects of injecting and recovering water from an aquifer should be considerably less than, for example, a new water supply dam.

The existing private abstraction bores accessing the Makauri Aquifer represent a significant capital investment. This aquifer, when actively replenished and managed, should be able to act as an effective water distribution system linking these bores with a GRS in addition to providing storage capacity. Investment and operational costs for a GRS in the Poverty Bay area are therefore primarily linked to developing and maintaining water injection and/or infiltration systems.

3 PROPOSED PILOT PROJECT

3.1 INTRODUCTION

The primary finding from the MAR pre-feasibility assessments (Stages 1A and 1B) was that a pilot trial is required to demonstrate the viability of a GRS focused on the Makauri Aquifer to improve the security of future water supply in the Poverty Bay area. Funding has been secured to design, plan and implement a MAR pilot trial based on the direct injection of water into the Makauri Aquifer. The primary source of injection water is the Mangapoike Dams, which are also the main source of potable water for Gisborne. During the initial development of the Pilot Project, a back-up source water option was also identified. This option entails the provision of water from the Waipaoa River through the Waipaoa Augmentation Plant.

3.2 LOCATION

The Pilot Project injection bore is to be located at the Waipaoa Augmentation Plant. This site has been selected for the following beneficial reasons:

- Proximity to two source water options:
    - Treated source water from Mangapoike Dams through the water supply pipe network, which also connects to the Waipaoa Augmentation Plant.
    - A back-up water supply option of Waipaoa River treated in the Waipaoa Augmentation Plant.
- The location of the site is several kilometres to the southwest of the area with the greatest density of Makauri Aquifer water takes as well as the greatest observed drawdown effects on the aquifer.
- There are only a few active bores with consented takes accessing the Makauri Aquifer close to the Pilot Project site. The bores associated with the largest consented groundwater takes are mostly located in the high use area to the northeast of the Pilot Project site. For this reason, groundwater level responses

to the injection trial at the planned monitoring bores are less likely to be masked by aquifer responses to pumping from individual private bores.

- The property located at the Waipaoa Augmentation Plant, is owned by and managed by GDC, allowing for easy access and permissions. In addition, this site also allows for on-going management of the injection bore and associated infrastructure by GDC if the Pilot Project demonstrates the viability of a GRS for the Makauri Aquifer.

3.3 INJECTION BORE CONCEPTUAL DESIGN

For costing purposes the injection bore is proposed to be up to 85 m deep, with a 6 m long screen. This initial design is based on Golder's interpretation of lithological logs from nearby bores. A pilot-hole will be drilled to confirm the lithologies at the site, prior to installation of the injection bore. The pilot-hole will be finished as a standpipe piezometer and used for monitoring of the groundwater level and water quality effects in the aquifer during the Pilot Project.

The injection bore will subsequently be constructed a few metres from the pilot-hole. The final bore design will be based on the outcomes from the pilot-hole drilling and may differ from the initial proposed design. The annulus spaces for both the standpipe piezometer and the injection bore will be sealed above the target aquifer to ensure no hydraulic connection develops between the Makauri Aquifer and any overlying shallow aquifer.

Injection of water will be closely monitored and controlled using flow control systems at the bore head. The injection bore head and flow control system will be inside a lockable shed to ensure site security. The source water for injection will be delivered to the site via an "off-take" from GDC's existing pipe network.

3.4 PILOT PROJECT SOURCE WATER OPTIONS

The project team has identified two potential source water options for the MAR pilot testing. The Primary Option is water from the Mangapoike Reservoirs, with a secondary (back up) option being source water diverted from the Waipaoa River via a Gisborne municipal augmentation plant. Past the project pilot testing, a combination of these options would likely be coupled with a range of other source water options if a full scheme is developed.

3.4.1 PRIMARY OPTION – MANGAPOIKE RESERVOIRS

Golder understands that up to approximately 117,000 m³ of water is potentially available from the Mangapoike Dams (Clapcott Dam and Williams Dam) and the associated Te Arai Bush Catchment between July and September for use in the Pilot Project. Water from the dams and bush catchment is treated at the Waingake Water Treatment Plant (WTP) and conveyed via gravity flow (with boosting as required) through the GDC reticulation system. This water is delivered as treated drinking water through the conveyance pipeline.

The water can be supplied to the Pilot Project at a rate of up to 15 L/s. GDC water supply engineers have stated that pipeline capacity is sufficient to supply both existing users and the Pilot Project outside the irrigation season. On this basis, sourcing water from the Mangapoike Dams is the preferred option for the Pilot Project. The amount of water actually available for the Pilot Project will be at the discretion of the GDC water supply engineers, who can provide the source water only after their supply requirements have been fulfilled.

The proposed MAR trial will involve installing a commercial standard "off take" in the water supply pipe line that feeds the tanker filling station located at the site. Flow meters are planned to be installed on the GDC supply side of the off take and at the injection flow control system at the bore head works.

3.4.2 SECONDARY OPTION – WAIPAOA AUGMENTATION PLANT

The Waipaoa Augmentation Plant was commissioned in 1991 as an alternative or back-up supply to augment the Waingake WTS, and could be used as a source of direct injection water for the Pilot Project. The plant has the capacity to produce water volumes up to 200 L/s or 17,000 m³/day (GDC 2008). GDC holds resource consent to take up to 13,392 m³/day from the Waipaoa River at the plant. These volumes would be easily sufficient for the purposes of the planned Pilot Project.

The regional arm of council has established a minimum river flow of 600 L/s at the Matawhero Bridge and 1.3 m^3/s at the Kanakanaia Bridge. Water take restrictions may be applied if the flows drop below these rates. Flows below these rates have however not been observed to date and restrictions have never applied (GDC 2008). For this reason, the risk of water flows from the Augmentation Plant being restricted during the trial is very low.

4 WATER QUALITY

4.1 OPERATIONAL WATER QUALITY MANAGEMENT REQUIREMENTS

A successful Pilot Project will be based on efficient replenishment of the Makauri Aquifer with high quality water. The quality of the source water used in the Pilot Project is important for the following reasons:

- The injection of the source water into the Makauri Aquifer and thereby mixing this water with the receiving groundwater should not result in a decline in the receiving water quality due to the introduction of contaminants with the source water.

- The use of good quality source water will help to manage the risk of chemical, biological or physical clogging of the injection well screen. In addition, well maintenance costs will be reduced if well clogging issues can be successfully managed through the use of good quality source water.

For the above reasons the quality of the water available from the Waingake WTP and the Waipaoa Augmentation Plant has been carefully assessed to ensure the above risks can be successfully managed during the Pilot Project.

4.2 GEOCHEMICAL ASSESSMENT

A geochemical assessment of the source water and groundwater quality has been carried out by Golder. The results of the water quality assessment show that the proposed sources of treated water are generally suitable for injection into the Makauri Aquifer at the Pilot Project site. The following points summarize the findings:

- Local groundwater is of reasonable quality and generally suitable for irrigation and livestock drinking. Dissolved iron and manganese concentrations slightly exceed long term trigger values for irrigation of sensitive crops.

- Alkalinity and hardness concentrations are elevated in the Makauri Aquifer, similar to water in the Waipaoa River, which originates from a limestone-bearing catchment. The hardness of groundwater has a moderate potential for fouling.

- Chloride concentrations in local groundwater increased between 2006 and 2015. The proposed MAR pilot injection water sources contain chloride at lower concentrations than are currently present in the local groundwater.

- Water supplied from the Gisborne City water supply is treated to drinking water standards and is of good quality.

- Free available chlorine present in the injection water should help prevent biological clogging by inhibiting the growth of the iron oxidising bacteria within the bore and around the screen.

- Generally low concentrations of dissolved metals (i.e. aluminium, iron, and manganese) in water from both sources, and in groundwater at the preferred pilot injection site, indicates that there is limited potential for chemical clogging.

- Seasonal iron concentration changes in water from local bores (i.e. higher concentrations in winter months and lower concentrations in summer months) may be related to near-well effects or changes in pumping activity in the bores. If these effects are also observed in groundwater at the injection well, a possible strategy to reduce the potential for chemical clogging may include pumping groundwater until iron concentrations decline to a stable level.

5 MONITORING

5.1 WATER LEVEL AND FLOW MONITORING

The flow of water into the injection bore will be carefully monitored at the bore head works. This data will be analysed throughout the injection trial so that the pressure responses in the aquifer can be analysed and assessed. The final project report will detail the flow rates and total volume of water injected into the Makauri Aquifer. The capacity for the injection flow rates and groundwater levels to be monitored in real time also provides opportunity for unexpectedly high groundwater levels to be identified and managed.

Groundwater level monitoring for the duration of the MAR pilot project and 3 months following is proposed for the nine targeted monitoring sites and one additional shallow bore. Water levels in the standpipe piezometer installed in the pilot hole will be monitored throughout the injection and recovery period. The planned monitoring program has been designed to enable mitigation measures to be applied during the project if any adverse effects are observed.

5.2 WATER QUALITY MONITORING

Groundwater quality will be monitored in three local bores as well as in the piezometer installed in the pilot drillhole. The objective of this monitoring is to gain a more accurate understanding of small water quality changes in the aquifer that may result from development of a wider GRS.

Acquisition of data in the following areas has also been included in planning of the Pilot Project:

- Drill cuttings will be collected for mineralogical analysis by X-Ray Diffraction and thin section petrography when the injection well is drilled. Mineralogical analysis could be used to identify minerals that may react due to changing chemical conditions in the aquifer.

- Dissolved and total iron concentrations will be analysed in samples collected from the piezometer installed in the pilot drillhole and from the closest production well to the pilot site monitored by GDC. The objective is to improve our current understanding of iron mobility in local groundwater.

- A down-hole camera inspection of the injection well screen will be performed following completion of the injection trial to confirm the effectiveness of the clogging management measures incorporated in operational procedures for the trial.

6 CONCLUSIONS

The proposed Poverty Bay MAR Pilot Project involves injecting treated water to the Makauri Aquifer through a specifically designed injection bore. Based on Golder's assessment of the aquifer hydrogeological characteristics and geochemical conditions, the proposed Pilot Project is not considered to have a significant effect on surrounding bore users or the aquifer. Data gathered during the Pilot Project will be carefully analysed during the injection trial so that the responses in the aquifer can be used to support the design of any future catchment GRS.

The planned monitoring program has been designed to enable mitigation measures to be applied during the project if any adverse effects are observed.

The proposed Pilot Project has been designed to generate information for the assessment of GRS options to support water management for the region. MAR has the potential to replenish and support sustainable groundwater yields from aquifers beneath the Poverty Bay Flats.

ACKNOWLEDGEMENTS

This Pilot Project is being carried out by Golder Associates (NZ) Limited on behalf of Gisborne District Council. The project has had guidance and input from the Freshwater Advisory Group (FwAG). Members of the FwAG, GDC and supporting organisations highly involved in the Pilot Project include Dennis Crone and Paul Murphy (GDC), Peter Williamson, Stuart Davis, Allan Horanga and Trevor Lupton. The Pilot Project has received sponsorship from Eastland Community Trust and Ministry for Primary Industry. We wish to acknowledge and thank the supporting organisations and members of the Pilot Project team.

REFERENCES

Doak M, Parminter I, Horgan G, Monk R, Elliot G 2004. The economic value of irrigation In New Zealand. Ministry of Agriculture and Forestry Technical Report 04/01, 65 p.

GDC 2008. Water Supply Activity Management Plan. Report prepared by Gisborne District Council, 2008. 136 p.

GDC 2011. Water demand forecasting – Gisborne water supply, Appendix 1. Report prepared by Gisborne District Council, December 2011.

Golder 2014a. Poverty Bay groundwater management. MAR feasibility Stage 1A – conceptual model. Report prepared for Gisborne District Council by Golder Associates (NZ) Limited. Golder report 1378110136-003. August 2014.

Golder 2014b. Poverty Bay groundwater management. MAR feasibility assessment and Goldsim groundwater management tool (Stage 1B). Report prepared for Gisborne District Council by Golder Associates (NZ) Limited. Golder report 1378110136-006. August 2014.