GROUNDWATER MONITORING: ARE WE GETTING THE FULL PICTURE

Katie Beecroft[a,b], Hamish Lowe[a], Sian Cass[a]

a. Lowe Environmental Impact, PO Box 4667, Palmerston North 4442
b. Corresponding Author. Email: katie@lei.co.nz.

ABSTRACT

Most land application systems, whether for municipal wastewater, biosolids and industrial wastewater require groundwater monitoring as a condition of consent. The potential for land application to cause nutrients, contaminants or pathogens to drain to groundwater is an important aspect in the design of a land application system. Monitoring of groundwater is the best way to determine if the system is achieving the level of renovation that it has been proposed when Resource Consent is applied for. However, the ability to accurately quantify the loss to groundwater is dependent on intercepting a contaminant plume. This requires a good understanding of the hydrogeology at and near to the application site.

Determining the location for installing monitoring bores needs to take account of the direction of groundwater flow, and the location of sensitive receptors e.g. groundwater fed surface water, and domestic water supply bores. The ability to intercept a contaminant plume requires consideration of groundwater stratification, as influenced by vertical and lateral diffusion and flow direction. Consideration needs to be given to how representative the sampling location is for assessing actual effects to receptors of the potential plume i.e. will attenuation, mixing and diffusion occur between the sampling location and receptors?

There have been several recent examples where historic monitoring of groundwater has shown no impact on groundwater as influenced by the land application activity. This is primarily due to the poor location and screen depth of monitoring bores. This in turn, has led to incorrect conclusions about the impact of the land application system on groundwater. This raises the question of "are we monitoring simply for the sake of monitoring?" This paper discusses one example in the Horowhenua district where groundwater monitoring suggested no impact from the land application and storage of wastewater on groundwater, where there was clear evidence that elevated nitrate was entering surface water via groundwater. Details of an exploratory groundwater program are given.

KEY WORDS

Land application, groundwater monitoring, contaminant plumes.

INTRODUCTION

Monitoring of land application systems includes the maintaining a watching brief of waste being applied, the soil environment, groundwater and surface water. Monitoring of the waste material enables quantification of the potential for contamination. Monitoring of the soil environment enables assessment of the degree of assimilation of the waste material. However, to determine if there is an effect beyond the application property monitoring of groundwater and surface water is needed. Surface water monitoring enables the direct (and indirect) measurement of an actual adverse effect, however it is often difficult to isolate how that effect might be attributable to a land application system. This is due to the large number of variables contributing to waterway health, and also the need to understand how and where contaminants from land application might enter a waterway. For instance, groundwater entering a stream may represent the inputs from 1 km upstream and beyond the land application site.

To determine if contaminants from the waste material are leaving a site, and therefore have the potential to cause an adverse effect, groundwater monitoring has the potential to be the most informative data. The ability to measure upgradient and downgradient concentrations provides a useful indication of changes due to activities on a site. In order to reliably determine these potential changes a sound understanding of the groundwater near the application site is needed.

GROUNDWATER MOVEMENT

Important parameters to enable the detection of contamination are:

- Direction of flow;
- Lateral speed/gradient;
- Pressure due to upwelling/downward pressure (water levels);
- Stratification of groundwater; and
- Diffusion potential of contaminants.

These properties help to determine the shape and behaviour of a contaminant plume, should it occur.

An understanding of these properties leads to good design of a groundwater installation and monitoring programme by enabling monitoring bores to be installed at a correct distance, direction and depth (total and screened) from the contaminant source and from sensitive receptors (which may include surface water).

There have been several recent examples where historic monitoring of groundwater has shown no impact on groundwater as influenced by the land application activity, when in fact more accurate recent monitoring has shown a significant impact. This is primarily due to the poor location and screen placement of monitoring bores. This in turn, has led to incorrect conclusions about the impact of the land application system on groundwater.

CASE STUDY

Site and Surrounds

The case study site is located in the coastal Horowhenua, 10 km south of the centre of Levin, 100 km north of Wellington and 1.5 km from the coast. Wastewater from Levin is treated at the town's WWTP and then pumped 7 km to a site known as the Pot. A large pond for the storage of treated wastewater is located in amongst sand dunes, which has the capacity to store over 400,000 m^3 of wastewater. The pond and surrounding area is shown in Figure 1 below.

The pond is surrounded by a Pine plantation which is irrigated with the stored wastewater. The irrigation scheme is now 25 years old and was originally set up to rely on the land to filter particulates, organic material and pathogens before intentionally draining to groundwater and then surface water. It has been successful at achieving these aims, but is now out of step with current best practice which should take into account nutrients and pathogens, and their effect on the wider water environment. With consent expiry looming, a good understanding of the effects to date were needed.

Figure 1: The Pot storage pond and irrigated plantation

Regional groundwater mapping provided initial information about groundwater flow in the vicinity of the site as shown in Figure 2 (the Pot at centre of figure). Dominant groundwater flow is west to the coast.

Figure 2: Groundwater movement near the Pot. Sourced: SMART Aquifer Characterisation Project Funded 2011-2017 by MBIE/MSI New Zealand (http://portal.smart-project.info/smart/mapviewer/wmc/horowhenua)

Historic Monitoring and Identified Issues

The initial consent required the installation of bores to measure groundwater levels. It is likely that the main purpose was to determine if the land application and pond were causing groundwater to mound. Over time occasional monitoring of water quality of those bores was undertaken. In the initial evaluation of likely effects from the storage and irrigation of wastewater, groundwater analyses suggested that only very minor increases in groundwater concentrations of contaminants occurred, and for a number of contaminants the upgradient (background) bore had higher concentrations than the downgradient (Pot influenced) bores. This was despite applications of 75 to 100 mm/week and approximately 4,000 mm/year.

Despite groundwater monitoring results showing low contaminant levels surface water monitoring of the nearby stream and on-site drains showed significant contaminant elevations, particularly of nitrate nitrogen. No sign of overland flow is present on the site and so groundwater was concluded as the likely conduit for nitrate to enter surface water. In addition, a water balance for the site indicated that a significant volume of the inflows into the storage pond were unaccounted for in the irrigation, which suggested that there was likely to be leakage from the storage pond.

Exploratory Programme

Further information was required to determine the fate of wastewater derived contaminants at the site. The initial investigation aimed to determine how groundwater moved horizontally at the site, including measurement of the groundwater gradient. The preferred method was to maximise the number of locations that measurements could be made, which in this case involved the installation of 20 mm diameter pipes at around 20 locations over the 100 ha site. This method allowed wide coverage for a comparatively small cost. Water levels over the course of a year were measured at the standpipes and in surface water drains with the aim of generating a potentiometric contour plan for the site.

Following the determination of groundwater levels and the resulting flow direction, locations were nominated for the installation of permanent monitoring piezometers. At these piezometers it was intended that water samples would be taken for analysis, rather than sampling the standpipes. At key locations nested piezometers were installed, whereby the total and screened depths for adjacent piezometers were different. This was to allow identification of the vertical distribution of contaminants within the groundwater system and contribute to an understanding of the potential contribution of leakage from the pond and the irrigation areas.

Results

Water level information gathered from the 20 standpipes and drain surveys enabled the preparation of a groundwater potentiometric map. The map suggested that groundwater mounding was occurring underneath the Pot pond (Figure 3). As shown in Figure 4, Section AA’, there is a general gradient towards the west (the direction of the coast) with an elevated mound in the vicinity of the storage pond. There is also a slight drop towards the south to surface water (the Waiwiri Stream).

The groundwater potentiometric map led to the choosing of the locations for the installation of monitoring piezometers, which approximately followed Section AA’. This included the installation of nested piezometers. Subsequent monitoring of water from the nested piezometers identified a wedge shape plume of nutrients moving from the pond towards the internal drains and coast. The nested piezometers indicated that the contaminants did not diffuse vertically to a great extent within the travel length of the plume monitored. Following the investigation, routine monitoring has been undertaken and there is now a high degree of certainty regarding the data to assist the redesign and consenting of a new irrigation system and storage management regime for the site.

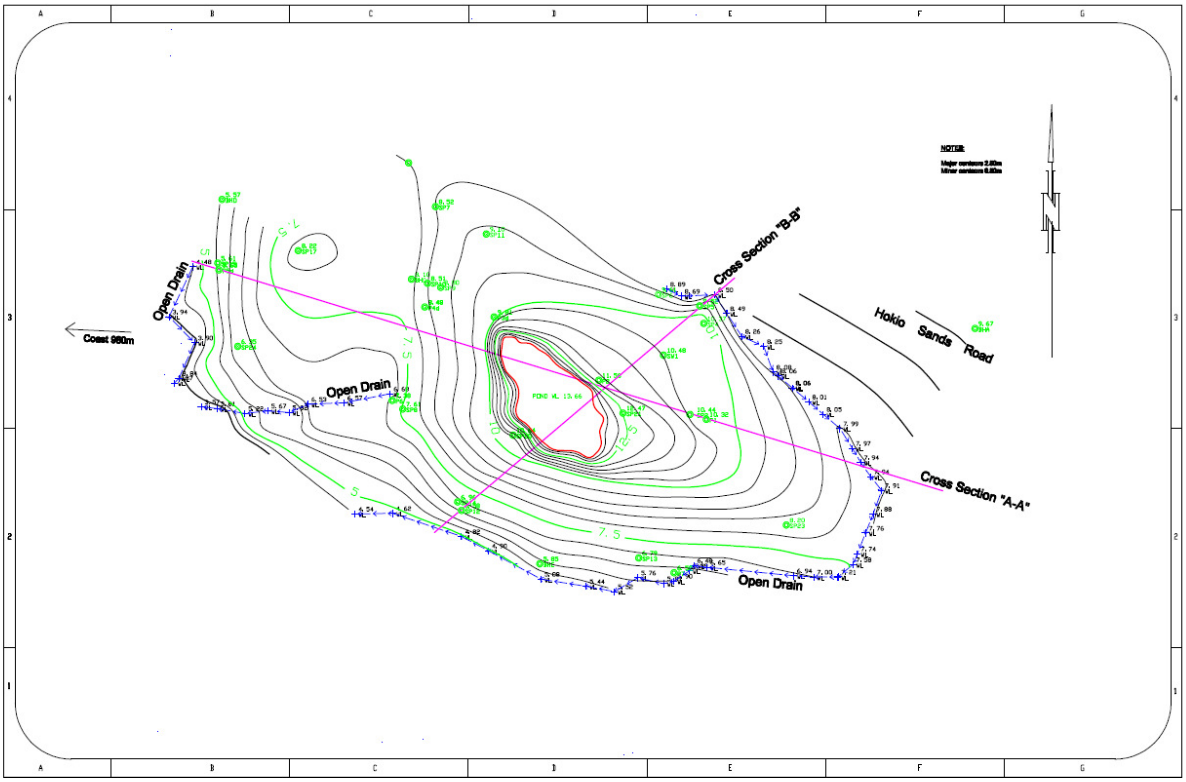

Figure 3: Groundwater Contours

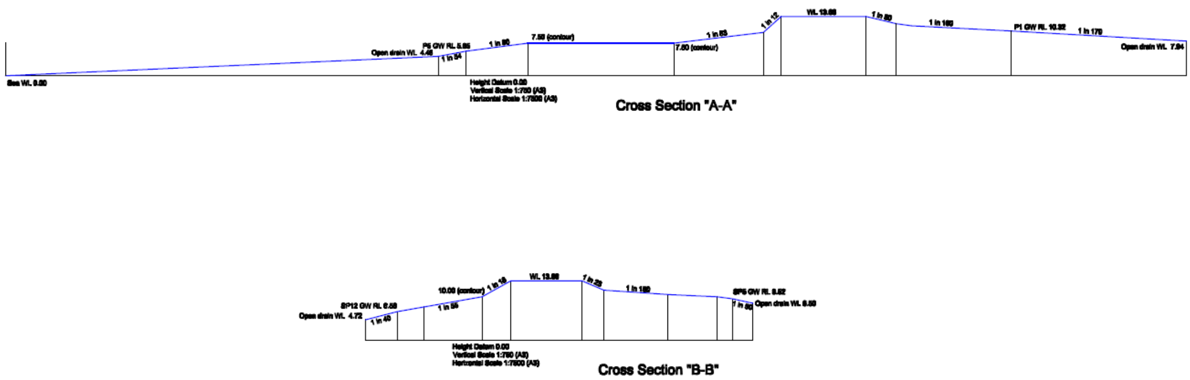

Figure 4: Groundwater Gradients Measured 24 April 2015

CONCLUSIONS

Groundwater monitoring is well suited to detection of a land application system's influence on the wider environment. It is frequently required as a condition of consent. Set-up is expensive so it is best to do it right the first time. In particular, there is a need to incrementally invest in understanding the hydrogeology of a site before long term monitoring piezometers are installed. Gaining an understanding of how a contaminant plume is likely to move from the site will enable the selection of appropriate sites and depths of bores which will intercept contamination, should it occur, and conversely appropriate locations for background bores. The extra certainty will reduce the number of piezometers that need to be installed and ultimately the number of samples for analysis. It will also help to accurately assess the contribution that groundwater contamination, if present, will contribute to impacts on surface water and the wider receiving environment.