GUIDELINES FOR DETERMINING SIGNIFICANCE OF ENVIRONMENTAL IMPACTS RESULTING FROM USE OF WATER FOR IRRIGATION

USE OF WATER MUST NOT COMPROMISE THE FOLLOWING OUTCOMES

LEVEL ONE

1.1 A sustainable environment.

LEVEL TWO

2.1 People are able to use natural and physical resources in ways that do not adversely affect the environment.

2.2 The environment in Canterbury exemplifies New Zealand's "clean green" image.

2.3 Tangata Whenua are able to exercise the relationship of their culture and traditions with ancestral lands, water, sites, wahi tapu and other taonga, and kaitiakitanga, in the management and use of natural and physical resources.

LEVEL THREE

3.1 Having access to water that is clean and safe to drink.

3.2 Water and aquatic ecosystems are healthy.

3.3 Water quality, flows and levels are not adversely affected by land use.

3.3 Wahi tapu and wahi taonga of value to Tangata Whenua are protected.

3.4 Sources of mahinga kai are safeguarded.

CIRCUMSTANCES WHERE THE IMPACTS RESULTING FROM USE OF WATER FOR IRRIGATION MAY COMPROMISE OUTCOMES BY MORE THAN A MINOR EXTENT

1. Where water is used to irrigate land for new or expanded[1] dairy farms[2]; <u>and</u>

2. Where the water is used within the capture zone[3] of bores used to supply potable water, or

3. Where the use causes more than 2 tonnes/annum[4] of NO_{3}-N to enter groundwater; or

4. Where the use causes concentration of NO_{3}-N in shallow[5] groundwater at any boundary to increase by more than the following:

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[1] Reference to maintaining water quality in policy statements indicate a tolerance for existing contamination, hence these guidelines focus on additional sources.
[2] Four factors drive this: significant expansion proposed following the lifting of the moratorium on expansion in early 2001; the trend for dairying properties to use large quantities of nitrogenous fertilizers which together with intensive stocking results in higher concentrations of nitrogen in drainage, compared with many other land uses; and the location of most expansion over unconfined groundwater.
[3] For the purpose of these guidelines, the capture zone is defined as the area around a bore where induced drawdown exceeds 100mm.
[4] This attempts to take some account of cumulative effects.
[5] After nitrogen is fully mixed within the upper two metres of aquifer.

- existing NO_3-N = 0-4 g/m^3 an increase of more than 1.5g/m^3;
- existing NO_3-N = 4-6 g/m^3 an increase of more than 1.0g/m^3;
- existing NO_3-N = 6-8 g/m^3 an increase of more than 0.5g/m^3;
- existing NO_3-N = 8-10 g/m^3 an increase of more than 0.25g/m^3;
- existing NO_3-N = >10 g/m^3 no increase; or

5. Where the use causes concentration of NO_3-N in groundwater entering surface water[6] to increase by more than 0.5g/m^3, and that groundwater contributes more than 10% of the flow; or

6. Where the use causes concentration of NO_3-N in surface water to increase by more than 10%.

METHODOLOGY FOR CALCULATION OF IMPACTS RESULTING FROM WATER USE

Increase in NO_3-N concentration of groundwater requires knowledge of drainage inflows and what happens once that drainage enters underlying groundwater.

Drainage Inflow

Volume of drainage entering groundwater following irrigation varies from 270 mm per annum for a thick[7] soil through to 600 mm for a thin[8] soil under border-dyke irrigation[9]. Without irrigation, respective volumes are 140 and 230 mm per annum. Increase in drainage depends on evenness of irrigation (K-line the worst, low pressure booms the best[10]); rate of application (the slower the better); and management (decision on how much water to apply). In the absence of actual data, assume an increase of 150[11] mm drainage per annum.

Three studies[12] demonstrate that concentration of NO_3-N in drainage beneath land used for intensive dairying is consistently around 12g/m^3 at drainage volumes of between 150 mm and 600 mm per annum.

Drainage inflow is calculated by multiplying the annual[13] drainage by the length of property parallel to the direction of groundwater flow[14]. This figure is multiplied by 12g/m^3 to obtain mass of NO_3-N entering groundwater each year.

Mixing in Groundwater

[6] And where that groundwater makes up more than 10% of the total rate of surface flow.
[7] Water holding capacity of 120 mm.
[8] Water holding capacity of 60 mm.
[9] Bowden et el, 1983. Interim report on the groundwater resource of the central plains. A report prepared by the Resource Investigations Division of the North Canterbury Catchment Board and Regional Water Board, Christchurch. Chapter 6.
[10] Figures presented to AEE Advisory Group meeting by Ian McIndoe, Lincoln Ventures.
[11] This assumes a very efficient irrigation system.
[12] Monaghan, R.N., Paton, R.J., Smith, L.C. and Binet, C. 2000. Nutrient losses in drainage and surface runoff from a cattle-grazed pasture in southland. *Proceedings of the New Zealand Grassland Association* ***62:*** 99 – 104.
Di, H.J. and Cameron, K.C. (2000). Calculating nitrogen leaching losses and critical nitrogen application rates in dairy pasture systems using a semi-empirical model. *New Zealand Journal of Agricultural Research*, ***43:*** 139-147.
Ledgard, S.F., Penno J.W., Sprosen, M.S. 1999, Nitrogen inputs and losses from clover/grass pastures grazed by dairy cows, as affected by nitrogen fertiliser application. *Journal of Agricultural Science, Cambridge*, ***132:*** 215-225.
13 This assumes drainage enters groundwater evenly throughout the year. If inflow is uneven resultant concentration will peak at higher concentrations, hence this is not a conservative assumption. Note 1 mm equates to 10g/m3 per hectare
[14] Orientation of the property relative to groundwater flow is therefore a significant factor in determining increase in NO_3-N concentration..

The manner in which drainage mixes with groundwater is poorly understood. A number of equations have been developed to simulate dispersion of contamination in groundwater but lack of field validation limits their usefulness. In the absence of more precise methods, use the following assumptions to calculate the volume of groundwater receiving the volume of drainage calculated above:

1. Average aquifer depth of 10 m
3. Assume complete mixing of drainage within upper two metres[15] of the aquifer at the downgradient property boundary.

[15] This can be increased if all down-gradient bores draw water more than 2 metres below the groundwater surface at all times.

WORKED EXAMPLES

Guideline 3: Effect on groundwater quality is potentially more than minor when the annual contribution of nitrogen from a farm is greater than 2 tonne.

- Concentration of drainage = $12 g/m^3$
- Additional drainage = 150mm (represented as $1,500 m^3/ha$ - $1mm = 10 m^3/ha$)
  (due to irrigation)
- Area of farm = A (ha)

Mass N = concn. x drainage x area

2,000 = 12 x 1,500 x A

$$A = \frac{2,000}{12 \times 1,500}$$

A = 111.1 hectares

Therefore, a dairy farm conversion or expansion of an area of land greater than 111 hectares could potentially have a more than minor effect on groundwater quality.

Guideline 4: Increase in N concentration at property boundary (See attached diagram).

Flow of groundwater	= $\mathbf{Q_n}$
Concentration of groundwater	= $\mathbf{C_n}$
Flow of input (drainage)	= $\mathbf{Q_i}$
Concentration of input	= $\mathbf{C_i}$
Concentration of output	**= $\mathbf{C_o}$**

Concentration of output

$$\mathbf{C_o = \frac{(C_iQ_i + C_nQ_n)}{(Q_i + Q_n)}}$$

For this example, property length = 700m, transmissivity = 2000, hydraulic gradient = 0.005

(1) Flow in groundwater (volume available for mixing per year)
Q_n = k x z x i x 365 days

- K = hydraulic conductivity
  =Transmissivity / aquifer thickness (assume 10 if no other info available)
- z = mixing zone, assume 2 m
- i = hydraulic gradient, obtain from GIS (see attached map).

- Q_n = K x z x i x 365

  = 200 x 2 x 0.005 x 365

= 730

(2) Q_i (flow of drainage)

- Additional drainage = 150mm (0.15m)
- Length of property parallel to direction of groundwater flow = 700m
- Flow = 700m x 1m x 0.15m = 105m^3

(3) Final concentration in groundwater (C_O)

- Eg. If concentration in groundwater = 3 g/m^3
- Concentration in drainage, C_i = 12g/m^3
- **Co = (C_iQ_i + C_nQ_n)/ Q_i + Q_n**

  = (12 x 105 + 3 x 730) / 105 + 730

  = 4.13
- Therefore increase is 1.13 g/m^3.