



# Transmission pathways of pathogens from domestic livestock to water - Quantify contamination of groundwater

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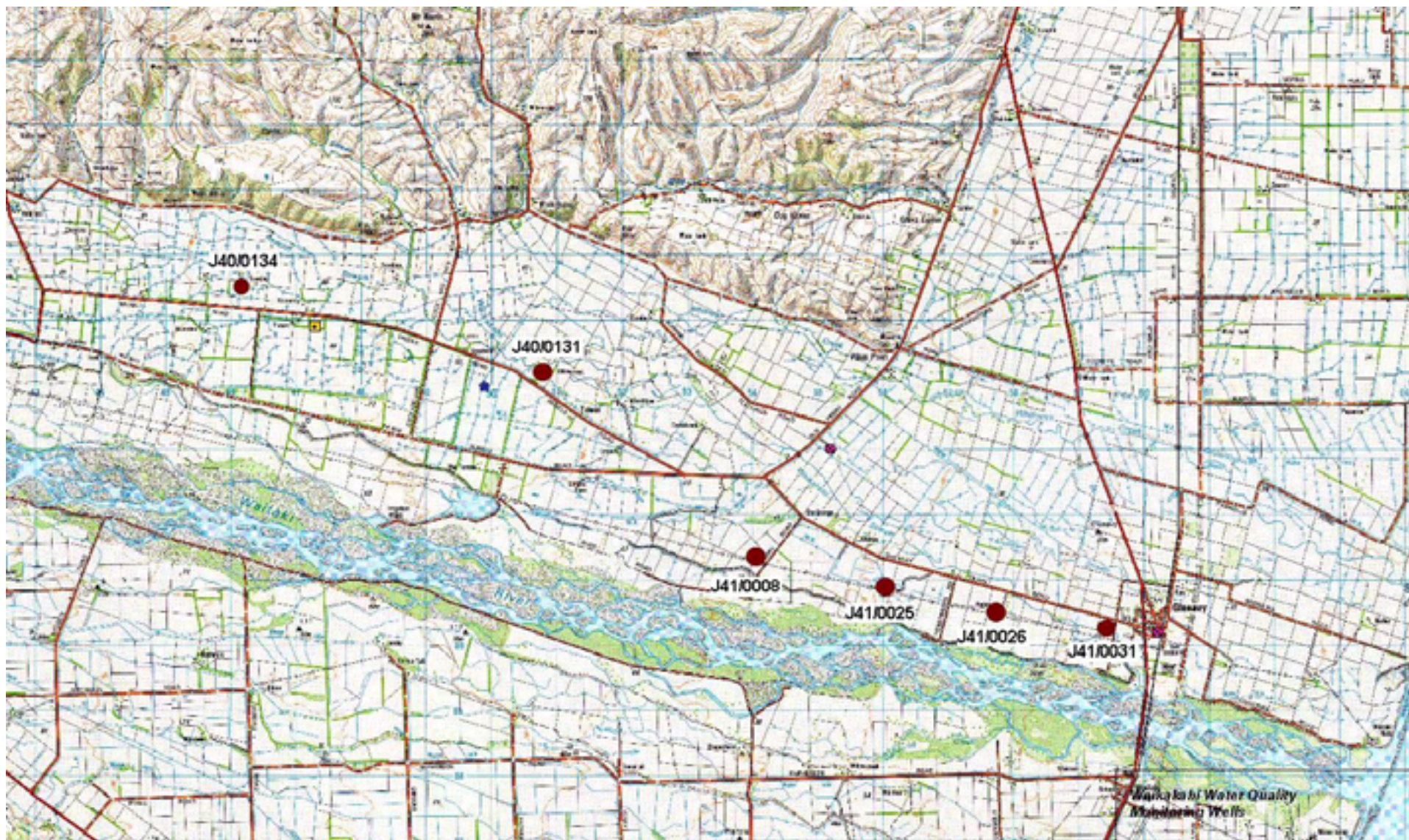
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# Project objectives

- Year 1: To quantify pathogen contamination of groundwater in a border-strip irrigation farming system.
- Year 2: To assess the impact of timing of stocking, irrigation and climatic factors on pathogen contamination of groundwater in border-strip and spray irrigation farming systems.
- Year 3: To derive best farming practices for border-strip and spray irrigation, in order to minimize microbial groundwater contamination.

# Methodology

- Six wells selected in Waikakahi catchment in consultation with ECAN
- Well selection criteria:
  - good wellhead protection,
  - no contamination from septic tanks,
  - reasonably shallow,
  - good access,
  - good cooperation from farmer



Well locations in Waikakahi catchment



## Methodology continued

- Wells sampled monthly during irrigation season and once during winter in year 1
- Wells sampled at varying frequencies in years 2 & 3
- Samples analysed for *E. coli*, total coliforms and *Campylobacter*
- In year 1 cow pats sampled on 6 farms every second month for presence of *Campylobacter* - 19/21 (90%) samples positive
- Irrigation and stocking information collected from the farmers

## Methodology continued

- CDRP supplemented a FRST funded project on microbial leaching from a medium intensity spray irrigation system near Te Pirita
- Data analysis of microbial groundwater data with stocking, irrigation and climate data
- Look at risks of drinking water with these levels of contamination
- Derive recommendations for management practices for border strip and spray irrigation systems in order to minimise microbial leaching

## Results from border strip irrigation

- Year 1: Seven sampling rounds during irrigation season
- One winter sampling round in September 2003
- Number of wells reduced to 5 - farmer had replaced his well - possibly as a result of our sampling & results
- Year 2: Five sampling rounds during irrigation season
- One month of intensive sampling for 2 wells
- Year 3: Weekly sampling of 5 wells for 2 months

## Results continued

- Total of 135 groundwater samples
- Total coliforms in all wells on all sampling occasions except 2 (99%); 1 in winter & 1 in summer.
  - levels range from <1 to >2400 MPN/100ml
- *E. coli* in all wells on at least one sampling occasion
  - levels range from <1 to 2400 MPN/100ml
  - overall detection rate during irrigation = 77% - 55% in winter
- *Campylobacter* detected in all 6 wells at least twice
  - levels range from <0.6 to >3.1 MPN/L
  - overall detection rate = 12%

## Results continued

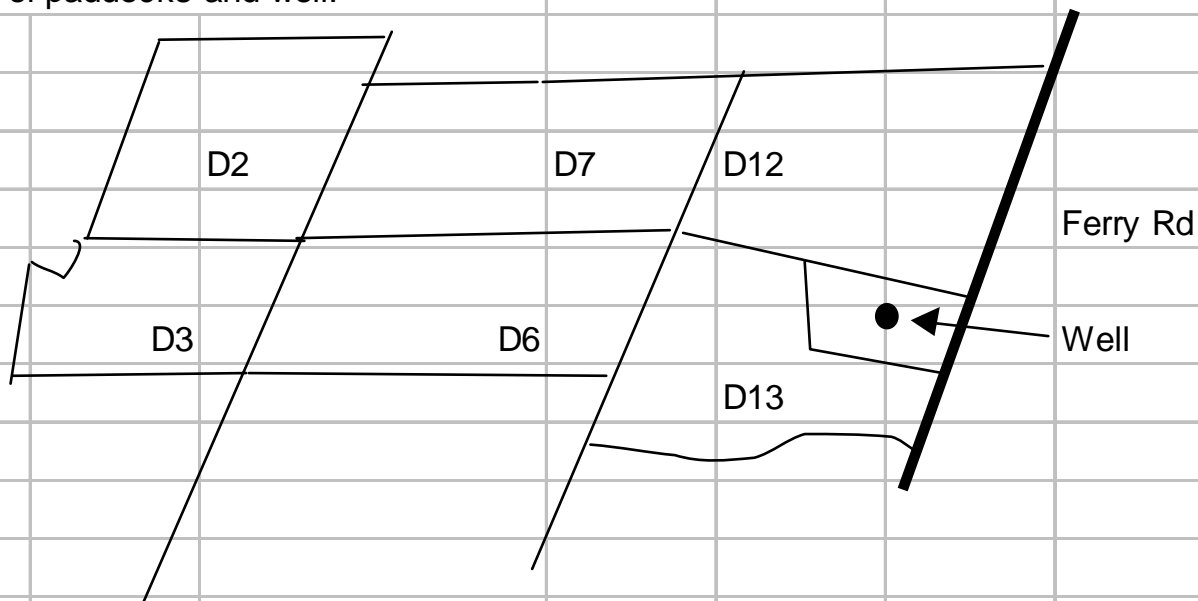
- Variable correlation between *Campylobacter* and *E. coli*
  - $r = 0.51$ ,  $p = 0.004$ ,  $n = 36$  in year 1
  - $r = 0.035$ ,  $p = 0.69$ ,  $n = 129$  for years 1 to 3
- No correlation between *Campylobacter* and total coliforms
  - $r = 0.02$ ,  $p = 0.82$ ,  $n = 129$

### Irrigation and Stocking data

Well number : J41/0008

Well owner :

Location of paddocks and well:

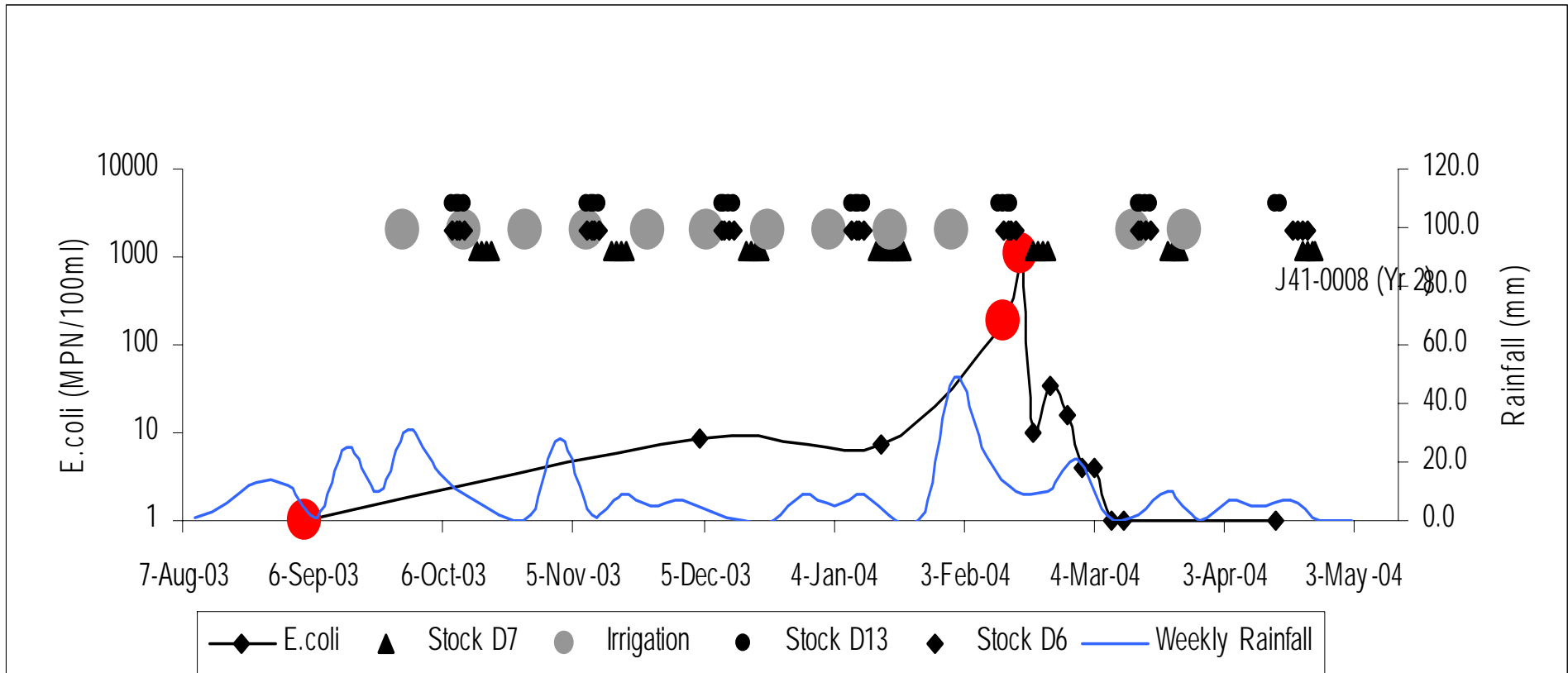


Paddock number : D2

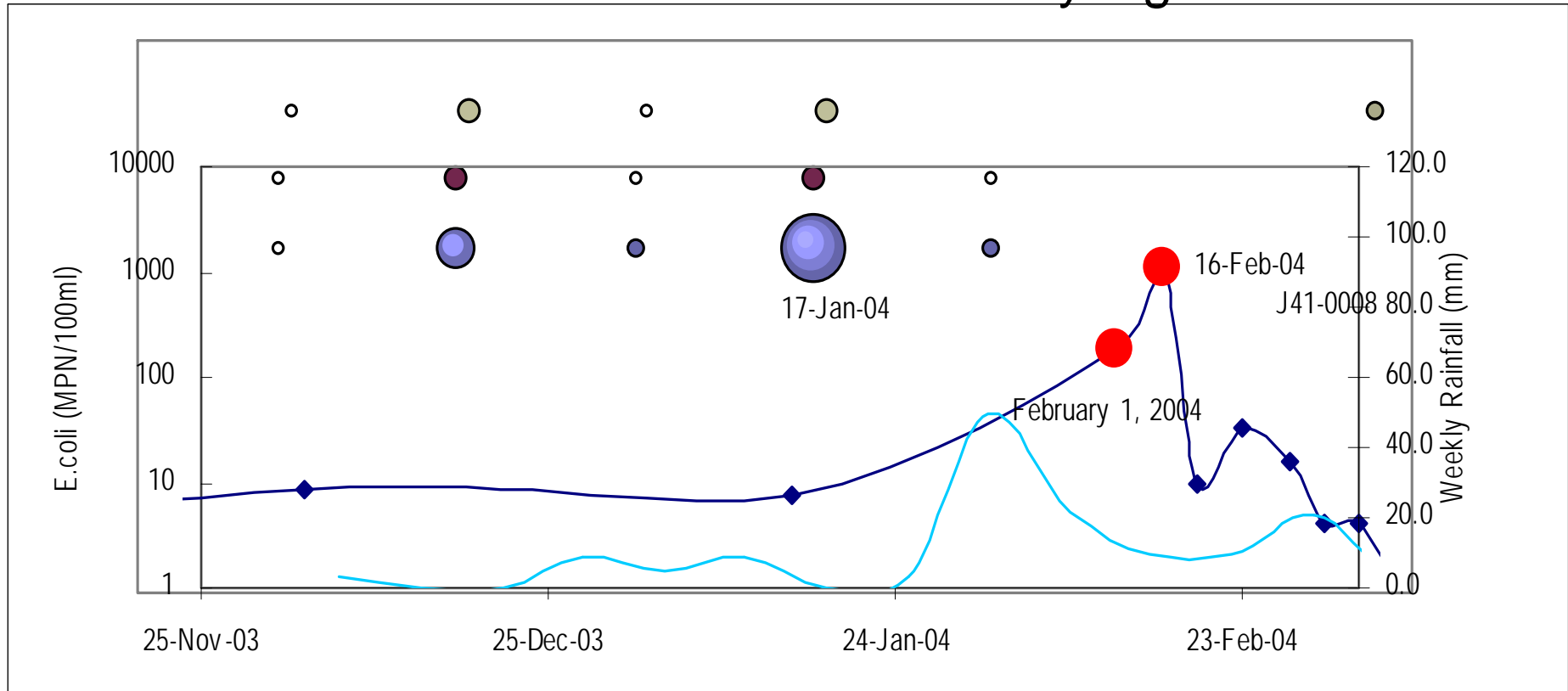
Paddock number : D6

Date	Irrigation	Stock

Date	Irrigation	Stock



# 30 day lag



## Results: Border Strip irrigation

- **Variable lags between “high risk” irrigation events & contamination**
- **Mostly 20-40 days**
- **Several factors could cause this variability**
  - variable distance from up-gradient paddock would result in variable arrival times
  - groundwater sampling frequency variable - biweekly to monthly
  - survival of bacteria dependent on temperature, UV, soil moisture
- **Relationship not as good as hoped for**

## Health risks of drinking water

- Numbers of Campylobacter ranged from <0.6 to >3.1 MPN/L; mostly <0.6 or 0.6 MPN/L
- Fitted an exponential distribution to the data
  - good fit with  $\beta = 0.28$
- Used standard dose response beta-Poisson curve (Black et al 1988; Medema et al. 1996)
- Consumption of 1-2 L/day
- Monte Carlo approach using @RISK
- For 2 L consumption,  $P_{inf} = 0.7\%$   
For 1 L consumption,  $P_{inf} = 0.5\%$

## Health risks of drinking water

- Daily probability of infection = 0.5 - 0.7%
- $P_a = 1 - (1 - P_d)^{182}$
- Probability of infection during irrigation season = 60% and 72%
- Sickness is probably 30-50% of the infection rate

# Health risks of drinking water

- **Landowners are concerned about groundwater quality**
- **At start of study, 5 out of 6 wells used for drinking**
  - 1 well replaced
  - 2 wells had filter systems installed
  - 1 well has filter on tap used for drinking

## Conclusions : Border strip irrigation

- Both pathogen and indicator bacteria are being detected in groundwater underlying dairying & border strip irrigation
- Well selection avoids septic tank and well head protection issues so contamination comes from this landuse
- Some relationship between microbial contamination, stocking & irrigation
- Significant health risk for drinking this shallow groundwater

# Recommendations

Issue can be addressed in 2 ways:

**1: Good quality groundwater for use for drinking & dairy sheds**

**2: Good microbial quality of groundwater underlying dairying & border strip irrigation**

# Recommendations

## 1: Good quality groundwater for use for drinking & dairy sheds

- Increase depth of well screens to  $> 30$  m below water table
- Treatment of water - eg, install filter system on well to remove pathogens
- Graze cows away from wells prior to border strip irrigation events
- Keep calves away from wells

# Recommendations

## 2: Good microbial quality of groundwater underlying dairying & border strip irrigation

- **Increase wellhead protection**
- **Avoid irrigation of pasture immediately after stocking**
- **More flexible access to water - is this possible?**
- **Improve efficiency of border strip irrigation**
- **Convert from border strip to spray irrigation**
- **Limit use of border strip irrigation to areas with deep soils that are not prone to macropores & have deep vadose zones**

# Recommendations

**Deliberately included a wide range of possible options.**

**No economic, social or technical assessment of feasibility of options has been carried out.**

**Some options are reasonably easy to carry out & will make a difference to water used on the farm & dairy shed - eg filters or deepening wells**

**Other options are much more difficult & may not be feasible**

**When given information, many farmers want to do something about it**

# Acknowledgments

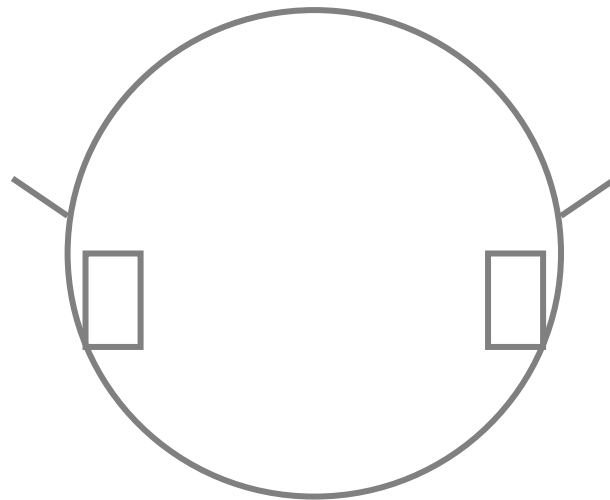
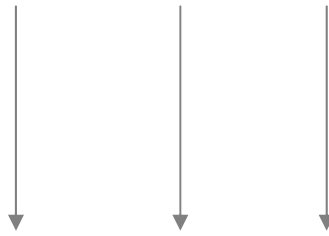
- **Farmers & well owners for access & co-operation**
- **Zella Smith, ECAN, for sample collection & farmer liaison**
- **Marion Savill, Andrew Ball & Rob Lake, ESR, for valuable discussions & comments**
- **Paula Scholes & Lauren Hollis, ESR, for microbial analyses**



The Linear Lysimeter & Dairying  
at Te Pirita



1.5 m



## Preliminary results from spray irrigation

- Collected 21 rounds of samples since January 2003
- 290 samples have been analysed for *E. coli*
- 129 samples have been analysed for *Campylobacter*
  
- Average irrigation application = 50 - 60 mm
- Very little microbial leaching with normal irrigation
  
- Increased irrigation amounts - around 80 mm
  
- No *Campylobacter* with irrigation up to 80 mm

## Preliminary results from spray irrigation

<b>Irrigation (mm)</b>	<b># of events</b>	<b>Mean E. coli (per 200 ml)</b>	<b>Max E. coli (per 200 ml)</b>	<b>Campy (per L)</b>
<b>50</b>	<b>16</b>	<b>&lt; 1- 1.3</b>	<b>&lt; 1 – 14</b>	<b>&lt; 0.5</b>
<b>80</b>	<b>4</b>	<b>72 - 550</b>	<b>400 – &gt;4000</b>	<b>&lt; 0.5</b>
<b>156</b>	<b>1</b>	<b>~ 1000</b>	<b>8000</b>	<b>&gt; 0.5</b>

## Conclusions : Spray irrigation

- Little leaching of bacteria with spray irrigation at depths of 50 mm
- More leaching of *E. coli* at application depths ~ 80 mm
- No detection of *Campylobacter* for application depths ~ 80 mm; but no fresh cow pats
- Lots of *E. coli* & *Campylobacter* with fresh cow pats and irrigation depth of 156 mm
- Need some further work on the limits for leaching