Installation of a dryland rainfall recharge lysimeter monitoring site at Ashcott Road, Ruataniwha Plains, Hawke's Bay

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DISCLAIMER

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EXECUTIVE SUMMARY

Groundwater resources in the Hawke's Bay region are relied upon for domestic, irrigation and industrial uses (Luba, 2001). In particular, the Heretaunga Plains and Ruataniwha Plains aquifer systems have an increasing demand for groundwater supply. Groundwater extraction generates pressure on these aquifer systems and requires careful management by Hawke's Bay Regional Council (HBRC). Understanding the volume and timing of rainfall recharge to aquifers is an important component of groundwater management. Rainfall recharge to groundwater occurs when precipitation infiltrates below the root zone into the aquifer. Quantifying rainfall recharge can be either estimated using models or at a rainfall recharge monitoring site, where direct evidence of the quantity and timing of rainfall recharge is provided (White *et al.*, 2007). HBRC previously commissioned GNS Science to install rainfall recharge monitoring sites on the Heretaunga Plains at Bridge Pa, Maraekakaho and Fernhill. In this report, a description is provided for the installation of a rainfall recharge monitoring site located in the Ruataniwha Plains. This network of monitoring sites will provide rainfall recharge information and assist HBRC with groundwater management.

1.0 INTRODUCTION

Groundwater resources in the Hawke's Bay region are utilised for domestic, irrigation and industrial uses (Luba, 2001). In particular, the Heretaunga Plains and Ruataniwha Plains aquifer systems have an increasing demand for groundwater supply. Increased pressure on these aquifer systems requires effective management by Hawke's Bay Regional Council (HBRC). Understanding the volume and timing of rainfall recharge to the aquifer systems is an important component of groundwater management. Rainfall recharge occurs when precipitation infiltrates the soil below the root zone to the aquifer system. Quantifying rainfall recharge can be estimated using models, or through direct measurements of the quantity and timing of recharge through lysimeters at a rainfall recharge monitoring site. A rainfall recharge monitoring site provides measurement of site specific groundwater recharge incorporating variation in soil properties, aquifer conditions and precipitation distribution (White *et al.*, 2007). Rainfall recharge sites have previously been installed in the Canterbury (White *et al.*, 2003), Bay of Plenty (White *et al.*, 2007; Lovett *et al.*, 2012) and Hawke's Bay regions (Lovett and Cameron, 2013).

HBRC contracted GNS Science to oversee the installation of three 500 mm diameter rainfall recharge lysimeters and an instrument enclosure at Ashcott Road, Ruataniwha Plains (Figure 1 and Figure 2). The monitoring site is located on well-drained soil, overlying an unconfined recharge area (Griffiths, 2004; Landcare Research, 2013). Rainfall recharge datasets from the site will complement datasets from previously installed sites in the Heretaunga Plains at Bridge Pa, Maraekakaho and Fernhill (Figure 3). Rainfall recharge information from the network of HBRC monitoring sites will be useful to estimate rainfall recharge across the Hawke's Bay region to assist in groundwater management.

The methods and materials used for installation of a dryland rainfall recharge monitoring site in the Ruataniwha Plains are documented in this report.

2.0 FIELD SITE AND LOCATION

2.1 FIELD SITE AND LOCATION

Installation of the lysimeter monitoring site was on property owned by the Bel Group, at 978 Ashcott Road, Ruataniwha Plains (E2798693 N6133107; NZMG1949) (Figure 2). The site location is approximately 1 km west of SH 50 from Ongaonga to Takapau, and 16 km east of Waipukurau. The Ruataniwha alluvial plains drain to the south-east and are bounded in the east by the Ruakaka Ranges and in the west by the Ruahine Ranges (Luba, 2001). The complex hydrogeological environment beneath the plains consists of multi-layered quaternary sand and gravel aquifers up to 150 m below ground level (Luba, 2001). The site is located on an unconfined area of the aquifer in the eastern region of the plains. At the time of installation, land-use in the paddock surrounding the monitoring site was dryland pasture for dairy cows (Figure 4).

HBRC liaised with the Bel Group Farm Operations Manager, Campbell Chard, to gain permission for the site instalment and access to the property. The monitoring site was selected by HBRC, GNS Science and Bel Group farm management (Figure 1 and Figure 4). Installation of the monitoring site began on Tuesday 18th June, 2013 and was completed on Tuesday 26th June, 2013. For the duration of the project, weather conditions were clear or overcast, with a light rainfall overnight (National Climate Database, 2013). High winds, cold temperatures and rain prevented field work on Friday 21st June following installation of the concrete enclosure.

2.2 LYSIMETER FABRICATION

HBRC contracted Lincoln Ventures to manufacture three rainfall recharge lysimeters. Each lysimeter was formed from 3 mm thick steel that was rolled and welded to produce a cylinder 700 mm high and 500 mm in diameter. A 95 mm wide circular plate was welded 100 mm below the top of the lysimeter to prevent soil consolidation around the outside of the lysimeter once installed. The ring was drilled with tapered holes to facilitate drainage. The lysimeter base plate was manufactured to be slightly concave (c. 10 mm) to promote drainage from the lysimeter.

A 32 mm diameter female pipe fitting was welded to the centre of the base plate for attachment of alkathene pipe fittings. An 8 mm thick by 50 mm wide bevelled steel ring was attached to the inside base of the casing to provide an internal cutting ring. The cutting ring provided a gap between the soil column and lysimeter casing that was subsequently sealed with petroleum jelly during the lysimeter preparation stage (Section 2.3.3). Four 800 mm long steel rods with a 100 mm long threaded end were provided to secure the base plate to the lysimeter casing. All lysimeter components were hot galvanised.

2.3 INSTALLATION PROCEDURE

2.3.1 Site setup

Once a suitable site was selected, a 'Before You Dig' request was processed to check for any underground utilities including gas, telephone and power lines. Consideration was made to locate the monitoring site as far as possible from nearby trees located around the paddock and along the nearby driveway. In addition, the site was selected to be as far as possible from nearby irrigation, which occurs to the east (Figure 5) and to the south-east (Figure 6). The site was designed to be as close to possible to the fence line in order to assist with installation of telemetry equipment and to minimise disturbance to farm operations. Test pits were dug on Monday 17th June to ascertain suitability of the soil conditions at the site (Figure 6 to Figure 8). A 2 m deep pit indicated a soil layer of approximately 500 mm which was underlain by gravelly sand, with no evidence of the water table (Figure 7). A site plan was then designed to ensure workable placement of the concrete enclosure, lysimeters and telemetry equipment along the driveway fence-line (Figure 8 and Figure 9).

2.3.2 Lysimeter removal

Each lysimeter casing was driven into the ground using a combination of weight from the hydraulic arm of the 8 tonne excavator and sledge hammers (Figure 10). The steel casing was protected by 1.2 m long, 125 mm x 125 mm house piles, and levels were used to check that the lysimeter was driven down vertically (Figure 10). Once the lysimeter had been driven 50 mm, grass sod was removed from around the lysimeter base. During driving, soil and stones from around the lysimeter base were excavated to facilitate driving of the casing and to decrease the risk of damage to the internal soil column. Difficulty was encountered around 500 mm below the ground surface, where gravels and boulders (> 100 mm diameter) were encountered (Figure 11 and Figure 12). Greywacke stones were either removed, or were broken under pressure and remained inside the lysimeter column. Each lysimeter was driven until the upper lip was approximately 15 mm above ground level (Figure 13). Following this, the pit was levelled (Figure 14) and the cutting frame was installed (Figure 15). A 10 tonne Porta Power was used to drive the cutting plate under the lysimeter and isolate the soil column (Figure 16). Four threaded rods were inserted through the eyelets at the top of the lysimeter and through the cutting plate, and then secured. A foam pad was placed on the grass at the top of the lysimeter and the head works were fitted to the top of the lysimeter. The c. 15 mm thick foam padding was put in place to ensure that the soil column inside the lysimeter did not shift during inversion. A swivel clamp was fixed around the centre of the lysimeter to prepare the column for lifting. The lysimeter was then lifted from the pit using the excavator and lifting chains (Figure 17) and inverted to allow for preparation of the soil base.

2.3.3 Lysimeter preparation

Each cutting plate was removed (Figure 18 – Figure 20) and the sediment was prepared so that the base of the lysimeter was level (Figure 21 – Figure 23). This allowed the base plate to be secured without any gaps. A circular layer of shade cloth was cut and placed on the soil base to stop fine material flowing from the lysimeter following installation (Figure 24). The base plate was inserted onto the rods and was temporarily bolted against the column. A 32 mm right-angle fitting, coupler and 15 mm reducer were attached to the base of the lysimeter (Figure 25). All pipe fittings were wrapped with thread tape prior to attachment, and were sufficiently tightened with an adjustable spanner.

The lysimeter was inverted and carefully lowered onto a timber platform. The rods were removed from the lifting position, and placed through the lower eyelets and the baseplate, then secured tightly. The lysimeter column was then cleaned of all sediment and solvents (Figure 26) in preparation for sealing. A Sika 291 marine sealant was applied sparingly and left to set overnight (Figure 27 and Figure 28). Subsequently, a 20 L bucket of Waxrex Petroleum Jelly was heated on a gas burner. Then a hand pump and copper nozzle were used to pump heated petroleum jelly inside the lysimeter casing to seal any gaps between the steel casing and soil column. A grinder was used to cut the additional length off the steel rods.

2.3.4 Installation of lysimeters and instrument enclosure

In order to assist with site re-establishment, the excavator was used to remove grass sod from a rectangular area around the enclosure. The pit was excavated and prepared for installation of the lysimeters and the concrete enclosure (Figure 29). Particular care was taken to create a 10 mm fall gradient away from the instrument end of the concrete tank, in order to facilitate drainage within the enclosure. A truck mounted crane was used to lift the 4500 L (3010 mm long by 1260 mm wide) concrete enclosure into the prepared pit (Figure 30). The enclosure was checked to ensure it was level (Figure 31). Once the enclosure was installed, string lines were set at ground level to assist with reinstallation of the prepared lysimeters (Figure 32) at the appropriate height relative to ground level and slope.

Each lysimeter was lifted using the excavator and safety strops (Figure 33). Cold weather conditions made it difficult to work with the 15 mm alkathene pipe, so boiling water was poured down the pipe lengths to straighten them. An approximately 3 m length of 15 mm diameter alkathene pipe was attached to the reducer at the base of the lysimeter. The lysimeters were then lowered into the pit using the excavator. Timber platforms of 1.5 m long, 125 mm x 125 mm treated house piles were installed (Figure 34 and Figure 35). During preparation of the platform, particular care was taken to ensure that the house piles were level and at a height that would allow the lysimeter casing to sit around 15 mm above the ground surface. Three holes were drilled through the concrete enclosure wall using a diamond drill and the 15 mm alkathene pipes were inserted through these holes (Figure 36 and Figure 37). A length of 65 mm diameter flexi-pipe (2.5 m to 3.0 m) was placed over the 15 mm alkathene pipe to protect it from crushing during infilling (Figure 36). A fall gradient of at least 100 mm was created from the base of the lysimeter fittings to the concrete enclosure to ensure rainfall recharge was transferred to the rain gauge without delay.

2.3.5 Infilling and site completion

Wooden lids were placed on the lysimeters and the enclosure was covered with plywood to prevent fouling from sediment. Infilling of the excavated area around the lysimeters was undertaken using the excavator and manually (Figure 38). Particular care was taken to ensure that the lysimeters were packed into the surrounding sediment, using a posthole rammer, to minimise subsidence following installation. The soil and turf were re-instated as close to natural profile as possible (Figure 39 and Figure 40). Installation of the rainfall recharge lysimeters and instrument enclosure was completed on 25 June, 2013 (Figure 41 – Figure 43). HBRC hold responsibility for the subsequent installation of tipping bucket rain gauges, data loggers, telemetry systems and other essential equipment to allow for operation of the rainfall recharge monitoring site.

2.3.6 Installation of soil moisture tubes

The National Institute of Water and Atmospheric Science (NIWA) recommended the installation of the neutron probes inside each lysimeter for soil moisture measurement (Duncan, 2013; Srinivasan, 2013). Hydroservices were contracted to install the soil neutron tubes. During the lysimeter installation, Hydroservices visited the site and inserted soil neutron probe access tubes into lysimeter two and three. A motorised hand auger was used to drill a c. 500 mm deep hole into each soil column (Figure 44 and Figure 45). A 400 mm long, 50 mm diameter aluminium access tube was then inserted inside the augered hole using a sledge hammer and weighted steel rammer (Figure 46 and Figure 47). Soil moisture was taken using the neutron probe and will provide a baseline for soil moisture in the lysimeters. A cap was placed on the top of the access tube to prevent water entering the lysimeter (Figure 48).

3.0 SOIL PROFILE

Soil at the site was identified to be a Takapau sandy loam, which is a Typic Allophanic Brown Soil (Landcare Research, 2013; Griffiths, 2004). The soil profile was characterised by a sandy loam with some ash (0 – 200 mm BGL) over an ashy sandy loam (200 – 370 mm BGL) (Appendix A). Beneath the loam soils lay a sandy alluvium (370 – 700 mm BGL) composed of greywacke stones (Appendix A; Griffiths, 2004). The loam horizons were cohesive and contained no gravels and fibrous roots. Greywacke rocks up to 200 mm diameter occurred in the alluvium below 370 mm BGL (Appendix A). The soil is well drained with a rapid permeability, and no impermeable barrier within 1 m BGL (Appendix B; Griffiths, 2004). Soil parent material is identified as Tongariro alluvium, sourced from volcanic ash and greywacke (Griffiths, 2004).

4.0 SUMMARY

A rainfall recharge monitoring site is an effective tool for measuring rainfall recharge to an aquifer. Datasets from rainfall recharge sites are an important information source for quantifying rainfall recharge and for groundwater management. HBRC commissioned GNS Science to oversee the installation of a rainfall recharge lysimeter site in the Ruataniwha Plains. Installation of the three 500 mm diameter lysimeters and a subsurface concrete instrument enclosure was completed on 25 June 2013. HBRC hold responsibility for subsequent installation of rain gauges for ground level and lysimeter measurements, fencing, and a telemetry system to complete the monitoring site. Once operational, the rainfall recharge site will complement those previously installed in the Heretaunga Plains at Bridge pa, Maraekakaho and Fernhill. This network of rainfall recharge monitoring sites will provide HBRC with rainfall recharge information suitable for groundwater management purposes.

5.0 REFERENCES

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FIGURES

Figure 1: Location of the Ruataniwha Plains dryland rainfall recharge monitoring site, Ashcott Road.

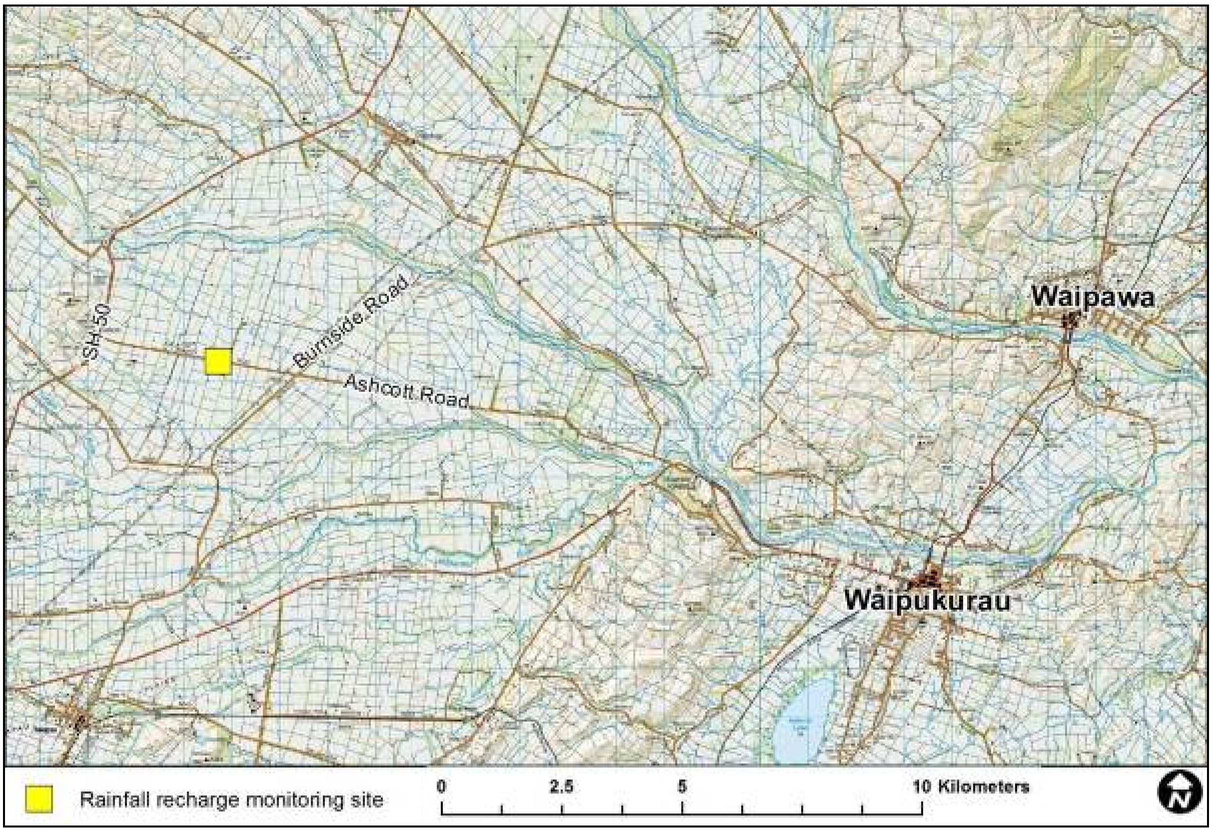

Figure 2 Location of the Ruataniwha Plains dryland rainfall recharge site in proximity to Waipawa and Waipukurau.

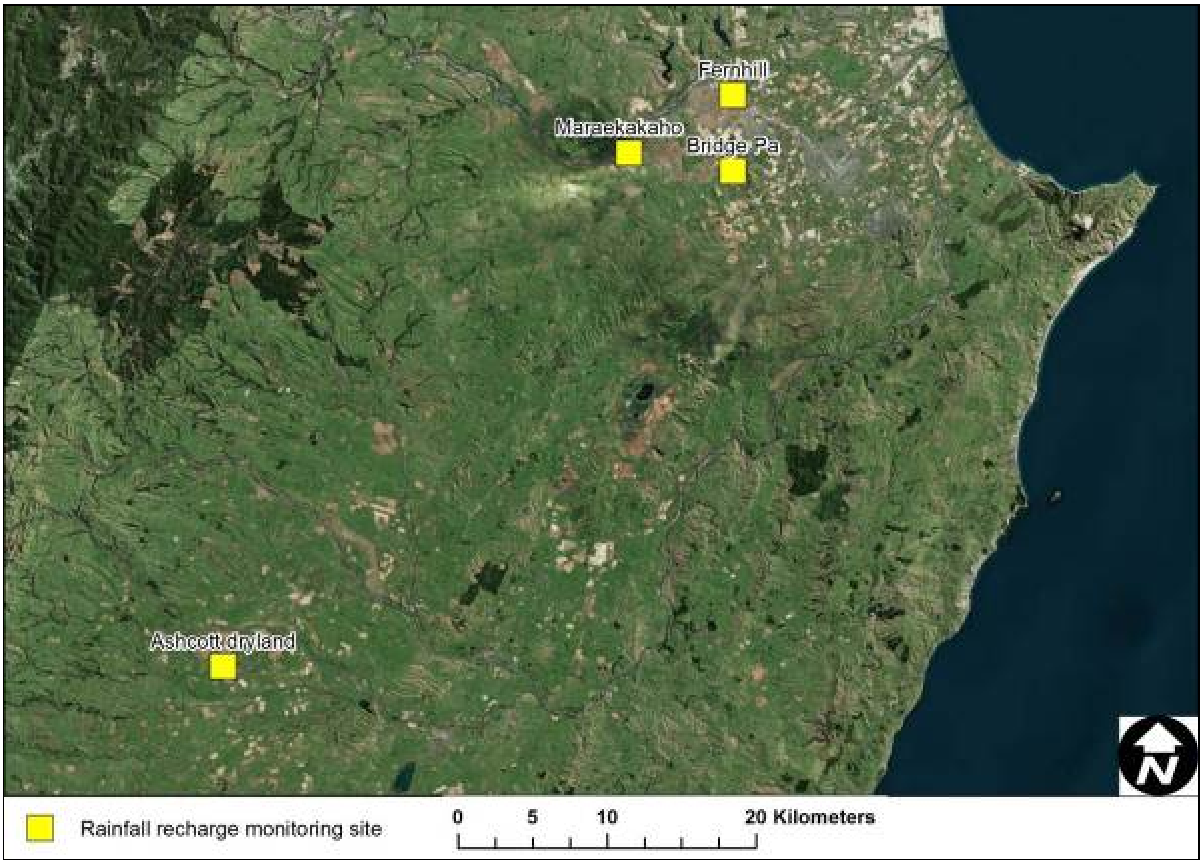

Figure 3: Location of HBRC rainfall recharge monitoring sites, Hawke's Bay.

Figure 4: Photograph of the selected site, photograph is facing north with Ashcott Road in the foreground.

Figure 5: Ruataniwha Plains dryland lysimeter site indicating the dryland paddock. All other areas are known to be, or likely to be, irrigated (refer to Figure 1).

Figure 6: Digging the test pit, photograph facing south-west of the monitoring site.

Figure 7: Two metre test pit showing loam soils overlying layers of gravel.

Figure 8: Initial layout of the monitoring site showing the test pit, enclosure, lysimeters and fence line for easy access and installation of telemetry equipment.

Figure 9: Initial site layout showing location of the enclosure and three lysimeters, facing west.

Figure 10: Driving of lysimeter one showing house pile and levels, following removal of grass sod.

Figure 11: At c. 500 mm BGL a gravel layer made driving of the lysimeter difficult.

Figure 12: Example of a greywacke rock (circled) broken under pressure during driving of the lysimeter.

Figure 13: Lysimeter one with the soil column c. 10 – 20 mm below the top of the lysimeter casing.

Figure 14: Preparing the pit around lysimeter one for the cutting frame and plate.

Figure 15: Levelling the cutting frame in the pit and preparing the plate for isolation of the lysimeter.

Figure 16: Lysimeter one after insertion of the cutting frame using the porta power pump.

Figure 17: Lifting lysimeter one from the pit with lifting chains, head works and swivel clamp.

Figure 18: Base of lysimeter one following inversion and removal of the baseplate.

Figure 19: Base of lysimeter two following inversion and removal of the baseplate.

Figure 20: Base of lysimeter three following inversion and removal of the baseplate.

Figure 21: Base of lysimeter one following preparation.

Figure 22: Base of lysimeter two following preparation.

Figure 23: Base of lysimeter three following preparation.

Figure 24: Shade cloth on the base of lysimeter three prior to fixing the base plate.

Figure 25: Inverted lysimeter following attachment of the pipe fittings.

Figure 26: Lysimeter one following cleaning and preparation for sealing.

Figure 27: Lysimeter one following sealing with Sika 291 marine sealant.

Figure 28: All three lysimeters following sealing.

Figure 29: Pit excavated and prepared with a sloping gradient, ready for the enclosure.

Figure 30: Lowering the concrete enclosure into the pit with a truck mounted crane.

Figure 31: Ensuring the concrete enclosure is level.

Figure 32: Lysimeters three, one and two (L-R) prepared and ready for re-instatement.

Figure 33: Attaching lifting strop to the lysimeter rods for re-instatement onto timber frames.

Figure 34: Lysimeter one and two installed onto levelled timber platforms.

Figure 35: Lysimeters on levelled timber platforms with alkathene pipes.

Figure 36: Lysimeters with alkathene pipe inserted into the enclosure and covered with flexipipe.

Figure 37: Pipe holes drilled through the concrete wall using a diamond drill.

Figure 38: Infilling of the pit, ensuring to re-instate the soil similar to natural profile.

Figure 39: Infilling of soil and re-instatement of grass sod to ground level.

Figure 40: Site completed with re-instatement of soil and grass sod.

Figure 41: Completed installation of three rainfall recharge lysimeters and concrete enclosure.

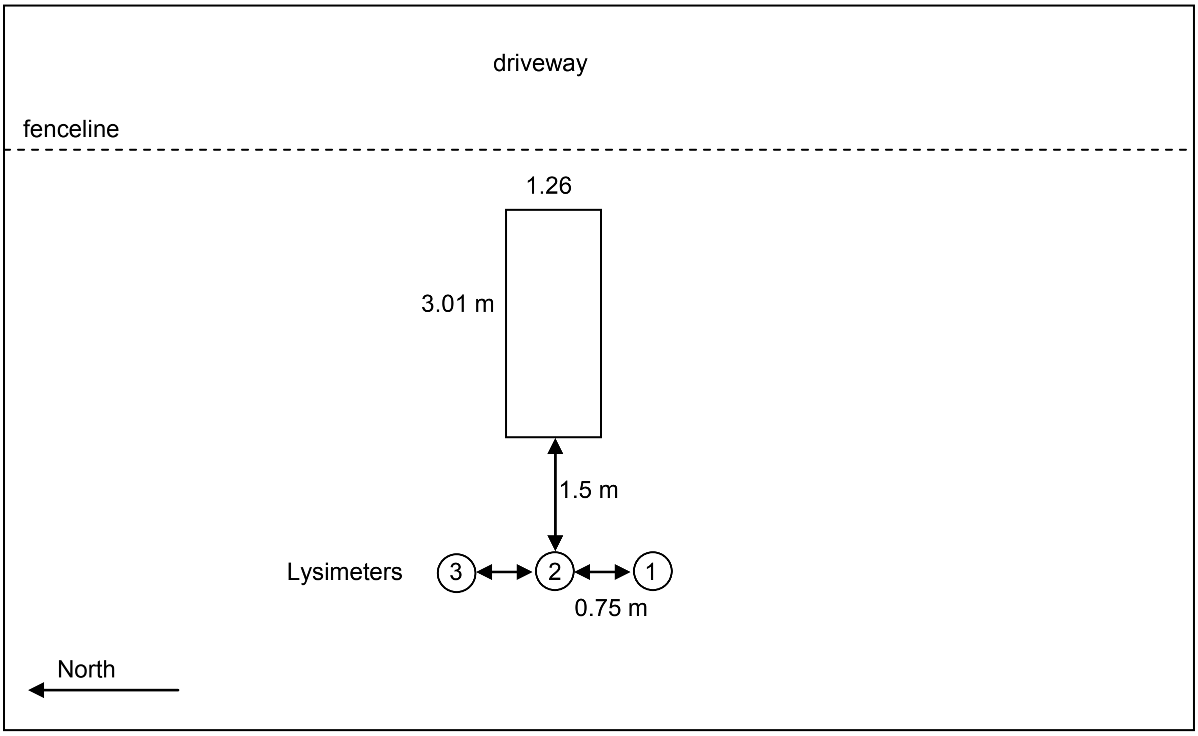

Figure 42: Diagram showing rainfall recharge site layout and orientation, refer to Figure 41.

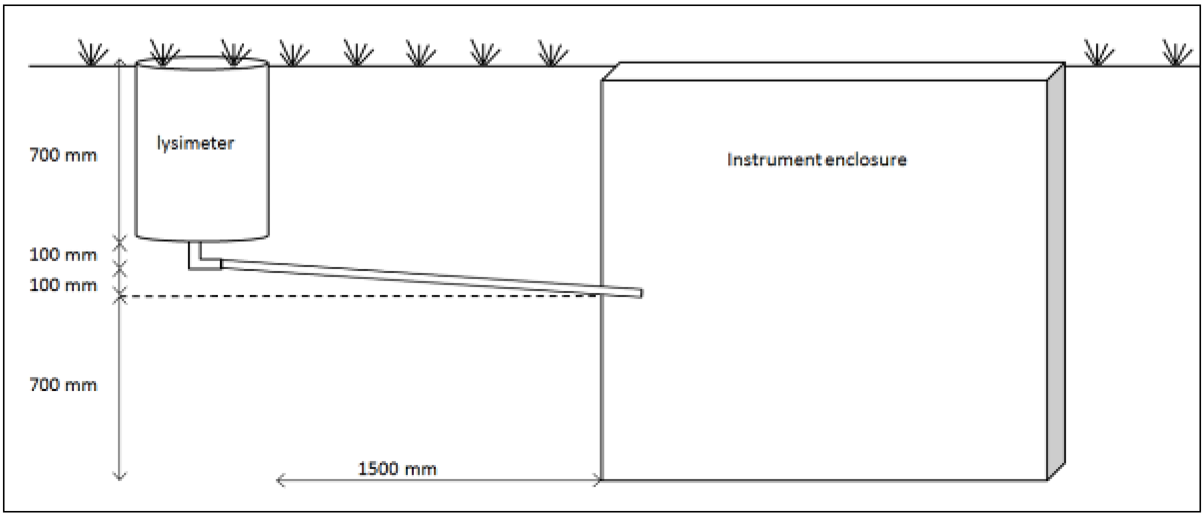

Figure 43: Cross section diagram showing the set-up of the lysimeter, pipework and instrument enclosure with approximate heights and distances.

Figure 44: Hydroservices using a motorised hand auger to drill a hole into lysimeter three.

Figure 45: Debris and hole that was drilled into lysimeter three for insertion of the neutron tube.

Figure 46: Sledge hammering the neutron tube into the ground prior to isolation of lysimeter two.

Figure 47: Neutron probe access tube inserted into lysimeter three.

Figure 48: Completed installation of neutron probe access tube and end cap into lysimeter three.

APPENDICES

APPENDIX A: SOIL PROFILE

Takapau (Griffiths, 2004)
Tararu*f* (Landcare, 2013)

Land cover: Pasture

Ground Level

Dark Brown sandy loam with ash
No gravels, cohesive
Tongariro ash

200 mm BGL

Brown ashy sandy loam
No gravels, cohesive
Tongariro ash
Fibrous roots

370 mm BGL

Brown sandy gravel, alluvium
very stony, fibrous roots
moderate F – C gravels
non-cohesive
greywacke

700 mm BGL
gravels

APPENDIX B: SOIL REPORT

Landcare Research
Manaaki Whenua

S-map Soil Report

Report generated: 7-Jun-2013 from http://smap.landcareresearch.co.nz

This information sheet describes the typical average properties of the specified soil to a depth of 1 metre, and should not be the primary source of data when making land use decisions on individual farms and paddocks.

Tararuf Tarar2z (100% of the mapunit at location (5572685, 1889929), Confidence: Medium)

S-map ref: Tarar_6.1

Key physical properties

Depth class (diggability)		Moderately Deep (45 - 65 cm)
Texture profile		Silty Loam
Potential rooting depth		Unlimited
Rooting barrier		No significant barrier within 1 m
Topsoil stoniness		Stoneless
Topsoil clay range		15 - 25 %
Drainage class		Well drained
Aeration in root zone		Unlimited
Permeability profile		Rapid
Depth to slowly permeable horizon		No slowly permeable horizon
Permeability of slowest horizon		Rapid (> 72 mm/h)
Profile total available water	(0 - 100cm)	Moderate (119 mm)
Top 60 cm available water	(0 - 60cm)	High (104 mm)
Top 30 cm available water	(0 - 30cm)	High (60 mm)
Dry bulk density, topsoil		1.09 (g/cm3)
Dry bulk density, subsoil		1.42 (g/cm3)
Depth to hard rock		No hard rock within 1 m
Depth to soft rock		No soft rock within 1 m

Key chemical properties

Topsoil P retention	High (66%)

Overseer values

Soil Order	Brown
Sand parent material	
Topsoil soil texture	
Depth	

About this publication

- This information sheet describes the *typical average properties* of the specified soil to a depth of 1 metre.
- For further information on individual soils, contact Landcare Research New Zealand Ltd: www.landcareresearch.co.nz
- Advice should be sought from soil and land use experts before making decisions on individual farms and paddocks.
- The information has been derived from numerous sources. It may not be complete, correct or up to date.
- This information sheet is licensed by Landcare Research on an "as is" and "as available" basis and without any warranty of any kind, either express or implied.
- Landcare Research shall not be liable on any legal basis (including without limitation negligence) and expressly excludes all liability for loss or

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Manaaki Whenua

Tararuf Tarar2z (100% of the mapunit at location (5572685, 1889929), Confidence: Medium)

S-map ref: Tarar_6.1

Additional factors to consider in choice of management practices

Vulnerability classes relate to soil properties only and do not take into account climate or management

Soil structure integrity

Erodibility of soil material	Minimal
Vulnerability to rill and slip erosion	not available yet
Structural vulnerability	Very low (0.37)
Pugging vulnerability	not available yet

Water management

Water logging vulnerability	Very Low
Drought vulnerability - if not irrigated	Moderate
Bypass flow	Medium
Hydrological soil group	A
Irrigability	Gently undulating land with good drainage/permeability and soils with high PAW

Contaminant management

N leaching vulnerability	Medium
P leaching vulnerability	not available yet
Runoff potential	Very Low
Bypass flow	Medium
Dairy effluent (FDE) risk category:	D

Additional information

Soil classification	Typic Allophanic Brown Soils
Family	Tararuf
Sibling number	6
Dominant texture 0 - 60 cm	Silty
Soil profile material	Moderately deep soil
Rock class of stones/rocks	From Hard Sandstone Rock
Rock origin of fine earth	From Hard Sandstone And Rhyolitic Rock
Parent material origin	Alluvium

Characteristics of functional horizons in order from top to base of profile:

Functional Horizon	Thickness	Stones	Clay	Sand
Loamy Weak	10 - 20 cm	0 %	15 - 25 %	25 - 60 %
Loamy Weak	35 - 45 cm	0 %	18 - 25 %	20 - 50 %
Very Stony Sandy Compact	35 - 55 cm	50 - 70 %	1 - 10 %	50 - 80 %

Landcare Research
Manaaki Whenua

APPENDIX C: EQUIPMENT LIST

COLLECTIVE EQUIPMENT		
cutting plate		
porta-power (pump)		
head clamp		
swivel clamp		
spare rods		
Petroleum Jelly Pump + nozzle		
Lifting strop		

CONSUMABLES		
Makita grinder blades		
Sika 291 marine sealant (x10)		
waxrex petroleum jelly		
gloves		
builders string		
spraypaint (dazzle)		
ladder (2.4m-3.9m Rhino)		
waratahs (1.5m x6hole)		
tape (Danger)		
125x125 House Pile sq. H5 1.5m (6)		
125x125 House Pile sq. H5 1.2m (10)		
PVC pipe 550.400.6sj 400 mm (4x700mm)		
Thread tape x 2-3 rolls		
Nylon reducers, couplers, bends - HYNDS		
Alkathene pipe & flexi-pipe - HYNDS		
LPG (gas bottle)		
Fuel (generator)		
fibreglass wick (6m)		
shade cloth		
marker pens (vivid)		
Insulation tape		
stockinette 500g (cloth)		
Nails - Flat, 100 x 4 galv 5kg		
180x42 RAD Permagroove H4 TG		
Fence Rail 75x50x4.5m RAD F2 H3.2 (3)		
Fence Post 100x100x2400 (6)		
Plywood non struc. H3.2 2400x18 mm (2)		
turps		
rubbish bags		

GNS GW EQUIPMENT		
spade		
sledge hammer		
levels (x 4 small; x 2 long)		
tape measures (2-3)		
tarpaulin		
Generator		
Billy / pot		
Extension cord		
Makita drill		
Drill set (1-13mm)		
gas burner (& regulator)		
gas bottle		
Makita grinder		
Plaster knives (2-3)		
Hand saw		
Scissors		
Toolbox		
Pipe wrench		
Posthole rammer		
Fire extinguisher		
Gazebo (good quality)		
Pipe cutters		
Sealant gun (good quality)		
Gloves for wick (lab)		
Storage boxes		

Additional GNS Equipment		
camera		
t-stick		
computer		
USB		

www.gns.cri.nz

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