URS

9 July 2010
Project No. 42170087.05000

Porters Ski Area Limited
c/- ORCA Partners
PO Box 2120
Bondi Junction
New South Wales 1355
Australia

Attention: Duncan Bull
Director

Dear Duncan,

Subject: Porters Expansion Project - Assessment of Stability of Wastewater Disposal Area (Revision B)

1 Introduction

URS New Zealand Limited (URS) was commissioned by Porters Ski Area Limited (PORTERS) to provide recommendations for the location of a shallow wastewater disposal field in order to ensure that slope stability adjacent to Crystal Stream and Porter River is not adversely affected by wastewater flowing out of the slope face. A significant volume of treated wastewater will need to be disposed of as part of the Porters Expansion Project; a development that includes accommodation, dining and skiing facilities. A 403,636 m^2 area within the Ski Lease Boundary has been defined by PORTERS as the maximum area available for disposal. We understand that the wastewater will be discharged to ground using a typical shallow subsurface dripper network consisting of rows of parallel lines placed at equal spacing of approximately 1 m.

Initially CPG New Zealand Limited (CPG) requested that we confirm slope stability within, and adjacent to, the proposed wastewater disposal area (project meeting 17 February, 2010). Subsequently CPG has explored the possibility of increasing the loading rate of the subsurface wastewater dripper irrigation lines and asked that the effects of a variable rate be modelled (email from Victor Mthamo, CPG, to Matt Howard, 22 April, 2010 and subsequent telephone conversations).

This letter outlines the analysis that has been undertaken and summarises the results, providing recommendations of setback distances from the channel edge for different application rates. This study has involved a desktop assessment of ground conditions that has involved the use of LiDAR topographic data and aerial photographs. In addition, a brief site inspection was conducted by Matt Howard and Mark Mabin of URS on 26 March 2010.

URS New Zealand Limited
URS House, 287 Durham Street
Christchurch, 8013
PO Box 4479, Christchurch 8140
New Zealand
T: 64 3 374 8500
F: 64 3 377 0655

2 Site Description and Geology

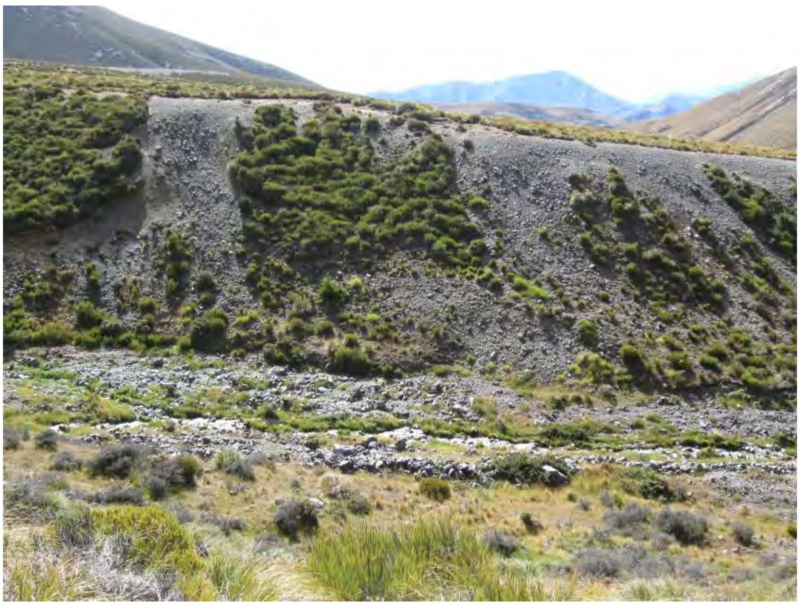
The proposed wastewater disposal area is bounded by Crystal Stream to the south, Porter River to the southeast and by the Ski Lease Boundary to the north (Drawing WW001). The foundation geology is similar to that in the proposed Village Base area, and consists of deposits that are either glacially deposited till or fluvio-glacial (glacial material that has been deposited by river processes) comprising silty/sandy gravel with cobbles derived from the surrounding greywacke sandstone (for a more detailed description of the regional geology, refer to the URS Geotechnical Summary Report, dated 22 April, 2010). These often form relatively low angle surfaces and their surfaces are characterised by dry stream channels formed by post glacial flood waters at the end of the last glaciation more than 12,000 years ago. Surface exposure shows that the gravel is unweathered and is loosely packed, which is typical of this material. Overlying this is an approximately 0.5 m thick layer of distinctive yellow loess silt, which is an air-borne post glacial deposit.

3 Land Stability Assessment

The Crystal Stream and Porter River channels have been formed within the post glacial fan deposit, resulting in adjacent slopes that are typically 20-40 m high and 30-40 degrees from horizontal, which is the natural angle of repose for the silty/sandy gravel. In the northwestern part of Crystal Stream the slope is up to 100 m high.

The preservation of ancient post glacial channels on the fan surface indicates that this area is stable. These channels are likely to carry water only during storm events and their catchment is limited. At the edge of this surface, the slopes adjacent to Crystal Stream and Porter River are mostly covered in vegetation and are at or near the angle of repose for gravel. Areas that are undergoing active erosion are highlighted by zones of little or no vegetation cover (see Figure 1). In these areas gravel material gradually rolls/bounces/slides downhill until a stable slope angle is formed.

Fig 1 Slope to the north of Crystal Stream, with the surface of the proposed wastewater disposal area above.



4 Seepage Analysis

A seepage analysis was performed to determine how close subsurface dripper lines could be located to the slope crest on the post-glacial fan surface without the water table rising above the slope toe. Water is a major controlling factor in the stability of slopes, and it is important that high volumes of wastewater inflows do not exit the slope.

The crest of the slope is defined in Drawing WW001. To the northeast, above the Porter River, this line is stepped back by approximately 100 m at the head of an ephemeral stream channel. This area is likely to have concentrated surface runoff during storm events and the additional setback reduces the possibility of wastewater encouraging greater surface storm flow.

As part of the analysis, seepage analysis was carried out using the finite element software in the program Slide (by RocScience). A simplified, typical cross section geometry was used to represent the discharge area, including:

- A horizontal top surface representing the discharge zone.
- A slope angle of 40 degrees from horizontal.
- A slope height of 40 m.
- A low permeability layer (i.e. greywacke bedrock), which was assumed to be present at a level 2 m below the base of the slope.
- A horizontal water table, which was assumed to be located at the base of the slope.

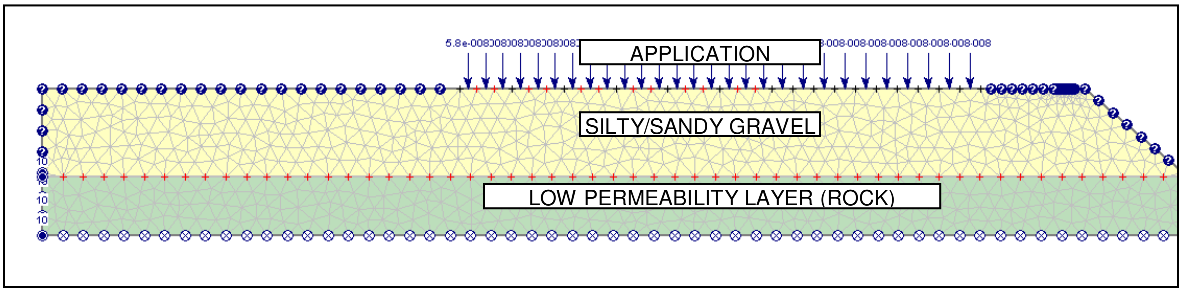
The above parameters are judged to be conservative and account for uncertainties in the model (i.e. depth to bedrock).

Data from four shallow depth infiltration tests were supplied by CPG (see attached Infiltration/Percolation Test Results), showing an infiltration range of between 240 and 320 mm/hr ($7x10^{-5}$ to $9x10^{-5}$ m/s). It is assumed that the dripper lines will be installed at a depth similar to where the infiltration tests occurred (buried in the ground below the loess horizon). We have assessed from our knowledge of the geology a permeability of no less than $1x10^{-5}$ m/s. This value has been used for the seepage analysis.

Once the model had been set up according to the parameters above (see Figure 2), an application rate of 5, 10, 15, 20, 30, 40 and 50 mm/day ($5.8x10^{-8}$ to $5.8x10^{-7}$ m/s) was separately applied. Several iterations were performed to identify how far the nearest infiltration could be to the top edge of the slope (see Drawing WW001) without the water table being raised above the slope toe. It was considered that when this occurs, the stability of the slope may become compromised.

Sensitivity analysis was also carried out for the ground permeability, using K values between $1x10^{-4}$ and $1x10^{-7}$ m/s.

Fig 2 Slide seepage model showing layers of differing permeability and the infiltration area (arrows)



5 Results and Discussion

The results of the seepage analysis are shown in Table 1 (see the end of this letter for graphical representations of the analysis). These show that for application rates of 5 and 10 mm/day for a ground permeability of $1x10^{-5}$ m/s, the distance between the application area and the crest of the slope is less than 5 m, without the water rising up the slope toe. If the application rate is increased to 15 mm/day, mounding of the water beneath the surface causes this distance to increase to 45 m. Increases in the application rate result in progressively larger setback distances (more than 225 m setback at 50 mm/day). The analysis suggests that it is possible that the bottom part of the slope may experience some seepage at the described offset distances. Very minor seepage, possibly resulting in evaporation, would not be expected to adversely affect the stability of the slope. The conservative assumptions of the model mean that such seepage is unlikely.

The model is sensitive to the permeability of the ground. For permeabilities of $1x10^{-4}$ m/s and application rates of up to 5-50 mm/day, the distance between the application area and the slope crest may be less than 5 m without the water rising up the slope toe. For the same application rate range in material with a permeability of $1x10^{-6}$ m/s, the distance between the application area and the crest is 250 m or greater.

This model uses conservative ground permeabilities to account for uncertainties in other aspects of the input to the analysis. Conservatism is expected to exist due to the permeability in the model being more applicable to the upper soils, where loess is present. At depth, where loess is absent or at lower concentrations, permeabilities would be expected to be higher. This is especially the case in the upper metre or so, where loess may be washed downwards by percolating groundwater. Permeability testing at depth would be required to determine if this was the case.

Table 1 Results of seepage analysis showing variation of distance from slope crest with permeability and infiltration rate. Shading denotes 'best estimate' design.

P Application Rate	K Soil Hydraulic Conductivity (m/s)	D Distance from slope edge (m)
5mm/day ($5.8x10^{-8}$m/s)	$1x10^{-4}$	**<5**
	$1x10^{-5}$	**<5**
	$1x10^{-6}$	250
	$1x10^{-7}$	>250
10mm/day ($1.2x10^{-7}$m/s)	$1x10^{-4}$	**<5**
	$1x10^{-5}$	**<5**
	$1x10^{-6}$	>250
	$1x10^{-7}$	>250
15mm/day ($1.7 x10^{-7}$m/s)	$1x10^{-4}$	**<5**
	$1x10^{-5}$	45
	$1x10^{-6}$	>250
	$1x10^{-7}$	>250
20mm/day ($2.3x10^{-7}$m/s)	$1x10^{-4}$	**<5**
	$1x10^{-5}$	100
	$1x10^{-6}$	>250
	$1x10^{-7}$	>250
30mm/day ($3.5x10^{-7}$m/s)	$1x10^{-4}$	**<5**
	$1x10^{-5}$	200
	$1x10^{-6}$	>250
	$1x10^{-7}$	>250
40mm/day ($4.6x10^{-7}$m/s)	$1x10^{-4}$	**<5**
	$1x10^{-5}$	225
	$1x10^{-6}$	>250 m
	$1x10^{-7}$	>250 m
50mm/day ($5.8x10^{-7}$m/s)	$1x10^{-4}$	**<5 m**
	$1x10^{-5}$	>250 m
	$1x10^{-6}$	>250 m
	$1x10^{-7}$	>250 m

6 Conclusions

The proposed disposal area is considered to be suitable for the discharge of treated wastewater. Slopes at the edge of the post glacial fan surface adjacent to the Crystal Stream and Porter River are naturally either stable, or have small scale erosion of their surfaces. It is judged unlikely that slope stability in these areas will be affected by wastewater discharge, as long as the setback distances outlined in Table 2 are followed.

7 Recommendations

It is recommended that the setback distances from the slope crest detailed in Table 2 are used in order to minimise the possibility of adversely affecting the stability of the stream slopes due to additional water seeping out of the slope face. Application rates of 40 or 50 mm/day are not considered practical, as the large setback distance means that the area for disposal is too small.

The offset lines are shown in Drawing WW001 and illustrate how the area available for wastewater disposal diminishes rapidly with increasing offset distance.

The analysis has made several conservative assumptions. If the discharge recommendations inhibit the development of the wastewater treatment area, then further infiltration testing may be warranted to better characterise the permeability of the subsurface.

Table 2 Suggested offset distance of wastewater disposal from the slope crest for different application rates, and associated disposal area (for a ground permeability of $1x10^{-5}$ m/s)

P	D	
Application Rate	**Distance from slope edge (m)**	**Approximate area for disposal (Ha)**
5mm/day ($5.8x10^{-8}$m/s)	5	31.3
10mm/day ($1.2x10^{-7}$m/s)	5	31.3
15mm/day ($1.7 x10^{-7}$m/s)	45	24.0
20mm/day ($2.3x10^{-7}$m/s)	100	15.8
30mm/day ($3.5x10^{-7}$m/s)	200	4.8
40mm/day ($4.6x10^{-7}$m/s)	NA	NA
50mm/day ($5.8x10^{-7}$m/s)	NA	NA

We trust that the information above meets your requirements. Please do not hesitate to contact us if you have any further questions.

Yours sincerely
URS New Zealand Limited

pp.

Matt Howard
Associate Engineering Geologist

pp.

Charlie Price
Principal Geotechnical Engineer

Attachments

Drawing PS087-WW001 Rev B

CPG Infiltration/Percolation Test Results

Document delivery

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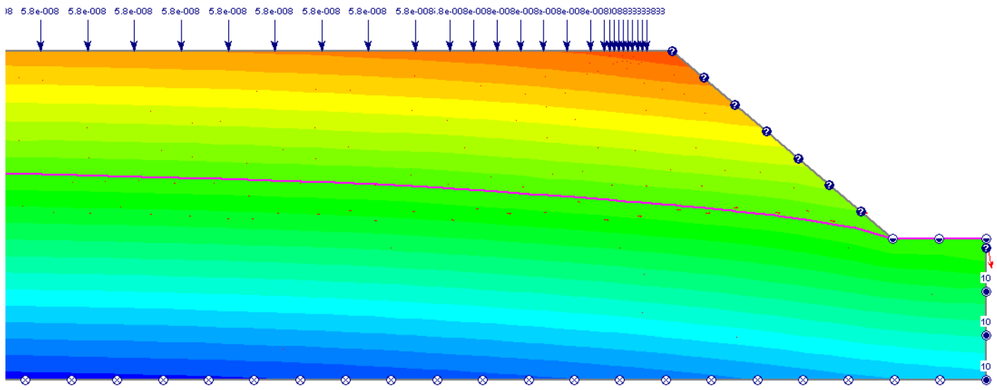
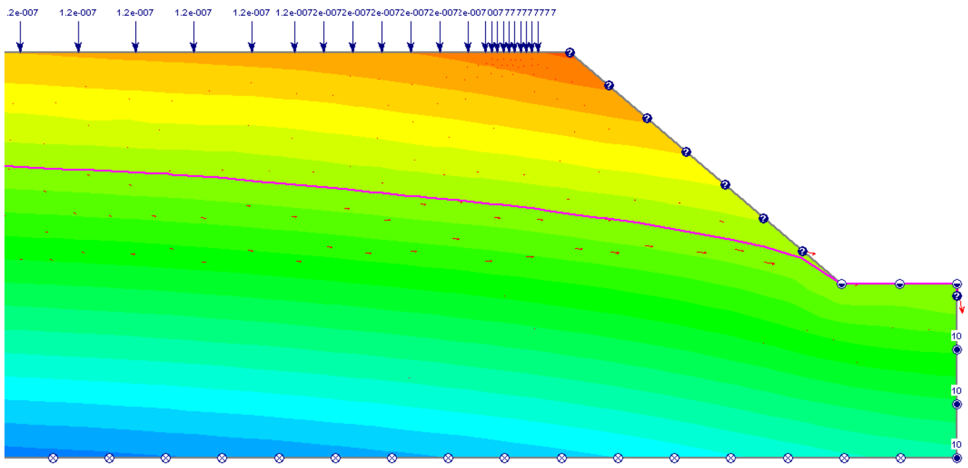
Where an electronic only version is provided to the client, a signed hard copy of this document is held on file by URS and a copy will be provided if requested.

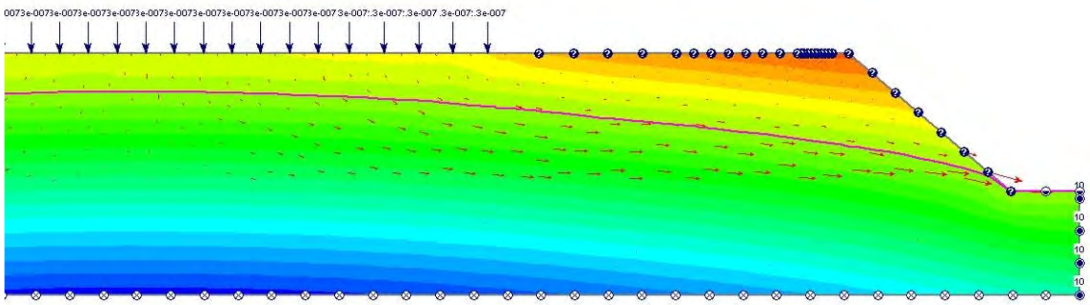
Appendix – Slide seepage cross sections



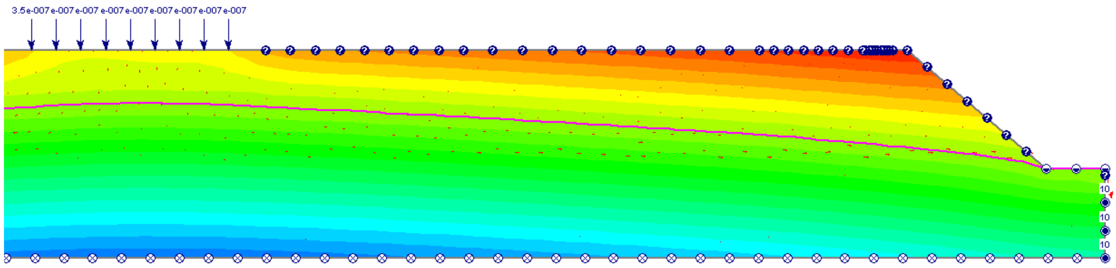
Infiltration rate of 5mm/day – 5m from edge



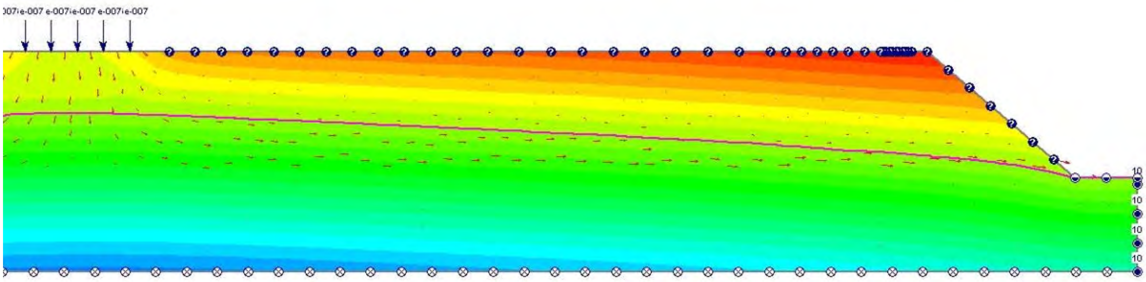
Infiltration rate of 10mm/day – 5m from edge



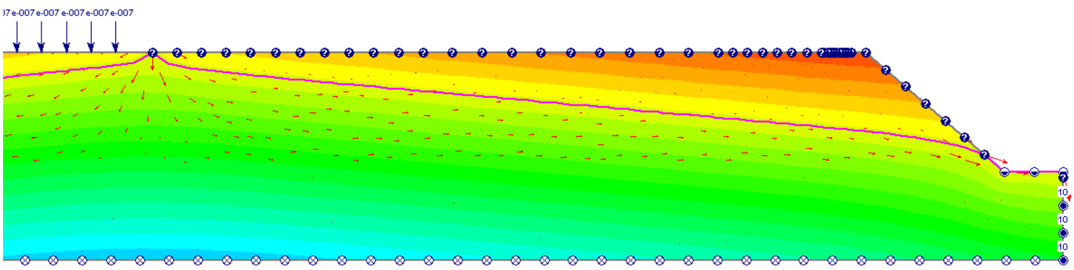
Infiltration rate of 20mm/day – 100m from edge



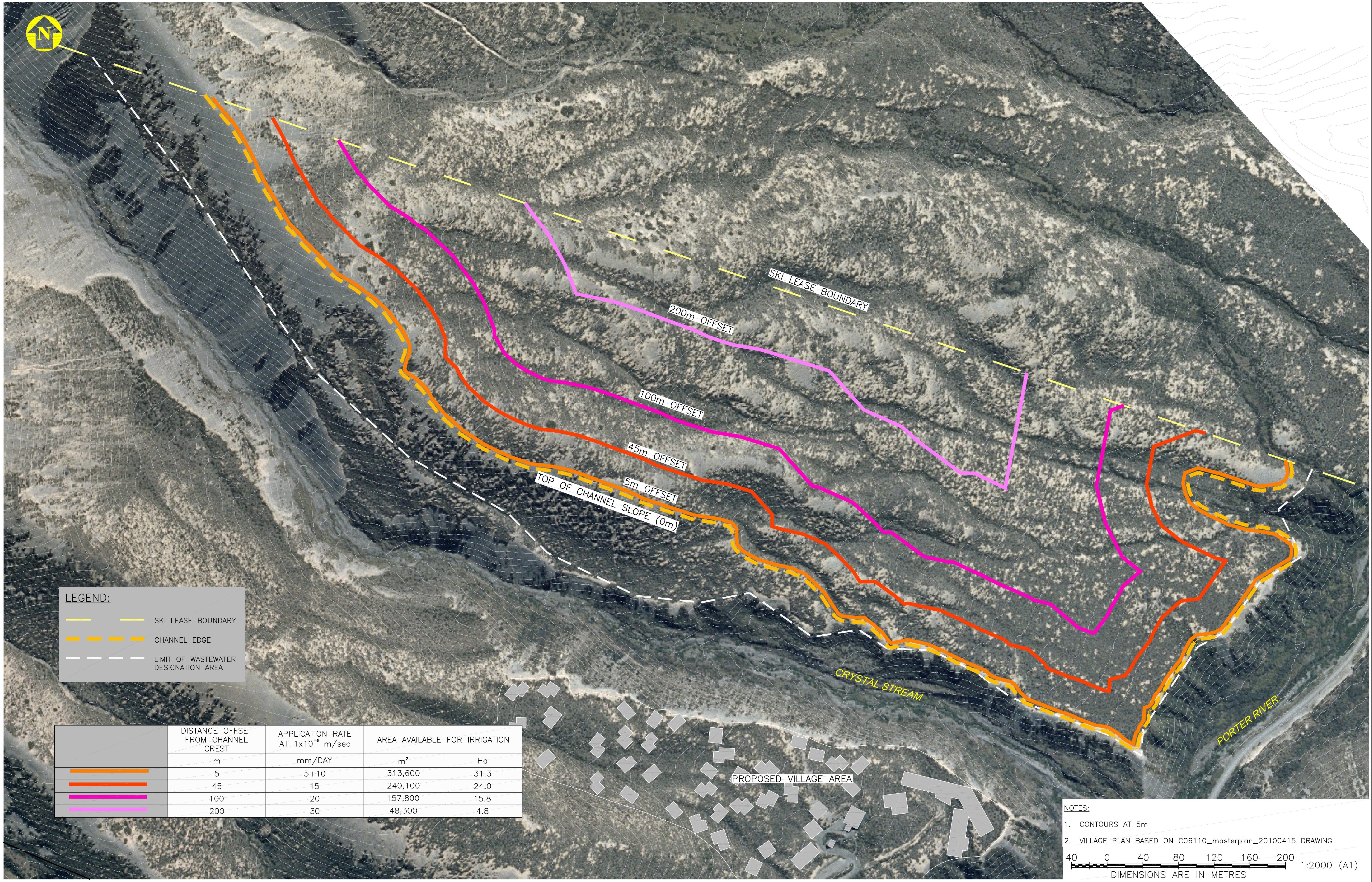
Infiltration rate of 30mm/day – 225m from edge



Infiltration rate of 40mm/day – 250m from edge



Infiltration rate of 50mm/day – 250m from edge



LEGEND:

- SKI LEASE BOUNDARY
- CHANNEL EDGE
- LIMIT OF WASTEWATER DESIGNATION AREA

	DISTANCE OFFSET FROM CHANNEL CREST	APPLICATION RATE AT $1x10^{-5}$ m/sec	AREA AVAILABLE FOR IRRIGATION	
	m	mm/DAY	m^2	Ha
(orange line)	5	5+10	313,600	31.3
(red line)	45	15	240,100	24.0
(magenta line)	100	20	157,800	15.8
(pink line)	200	30	48,300	4.8

NOTES:

1. CONTOURS AT 5m
2. VILLAGE PLAN BASED ON C06110_masterplan_20100415 DRAWING

40 0 40 80 120 160 200 1:2000 (A1)
DIMENSIONS ARE IN METRES

Rev	Revision Description	Designed	Drawn	Checked	Approved	Date
B	FINAL ISSUE	MH	GK			Jul 2010
A	DRAFT	MH	GK			Apr 2010

Tab WW001
Scales 1:2000 at A1 1:4000 at A3
Original Size A1

URS New Zealand Limited
Level 5, URS House
287 Durham Street, Christchurch
Phone: 3-374 8500
Fax: 3-377 0655

PORTERS

PORTER EXPANSION PROJECT

WASTEWATER SETBACK DISTANCES FOR SLOPE STABILITY FOR GROUND PERMEABILITY OF $1x10^{-5}$ m/sec

Status: FINAL
Drawing Number: PS087-WW001
Revision: B

J:\Jobs\42170087\5 Works\Drawings\Current Drawings\PS087_WW001.dwg Printed by: Galina Koulikova 12-Jul-10

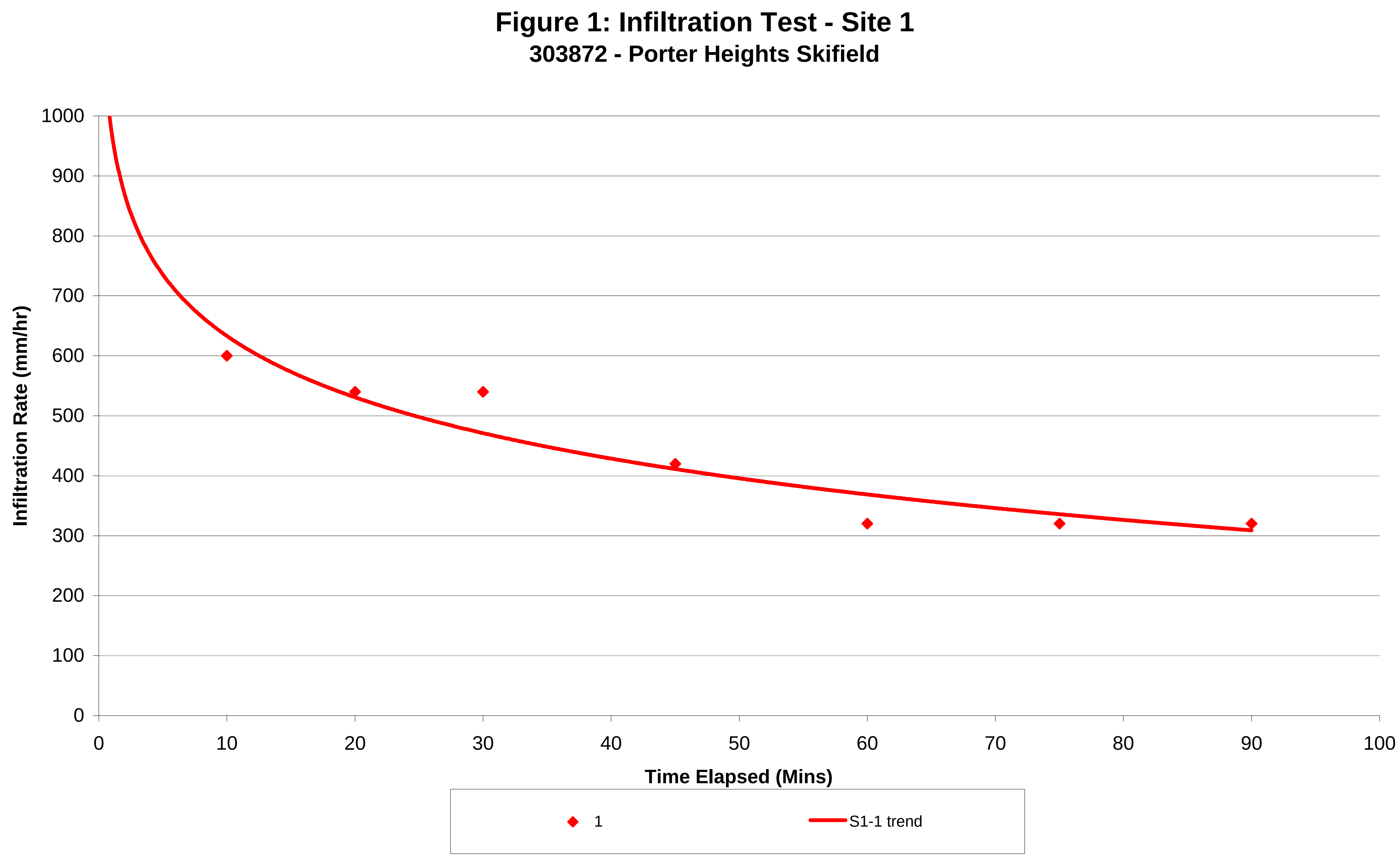


Figure 1: Infiltration Test - Site 1
303872 - Porter Heights Skifield
1000
900
800
700
600
500
400
300
200
100
0
Infiltration Rate (mm/hr)
0
10
20
30
40
50
60
70
80
90
100
Time Elapsed (Mins)
1
S1-1 trend

Infiltration/Percolation Test Results

Duffill Watts Consulting Group

Job Number: 303872
Site: 1
Date: 23/02/2008
Method: Falling Head Infiltration Test
Convert: n
Easting 2401411
Northing 5768960

Time (24 hr)	Depth (mm)	Rise/fall conversion	t change (mins)	Accum t (mins)	d change (mm)	d/m (mm/hr)	Notes
9:00	665	-665		0			
9:10	565	-565	10	10	100	600	
9:20	475	-475	10	20	90	540	
9:30	385	-385	10	30	90	540	
9:45	280	-280	15	45	105	420	
10:00	200	-200	15	60	80	320	
10:15	120	-120	15	75	80	320	
10:30	40	-40	15	90	80	320	

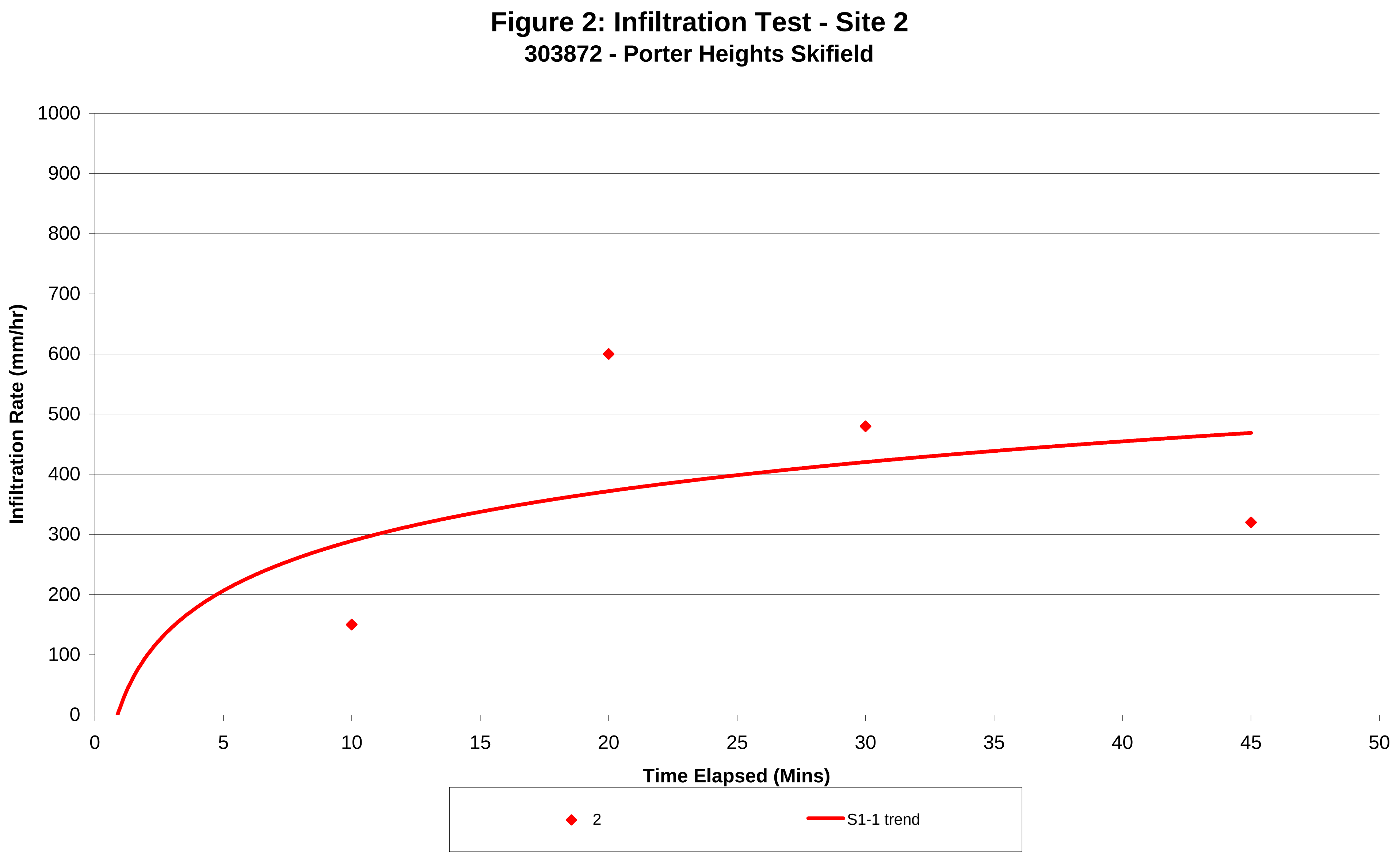


Figure 2: Infiltration Test - Site 2
303872 - Porter Heights Skifield
Infiltration Rate (mm/hr)
1000
900
800
700
600
500
400
300
200
100
0
0
5
10
15
20
25
30
35
40
45
50
Time Elapsed (Mins)
2
S1-1 trend

Infiltration/Percolation Test Results

Duffill Watts Consulting Group

Job Number: 303872
Site: 2
Date: 23/02/2008
Method: Falling Head Infiltration Test
Convert: n
Easting 2401467
Northing 5769026

Time (24 hr)	Depth (mm)	Rise/fall conversion	t change (mins)	Accum t (mins)	d change (mm)	d/m (mm/hr)	Notes
9:00	330	-330		0			
9:10	305	-305	10	10	25	150	
9:20	205	-205	10	20	100	600	
9:30	125	-125	10	30	80	480	
9:45	45	-45	15	45	80	320	

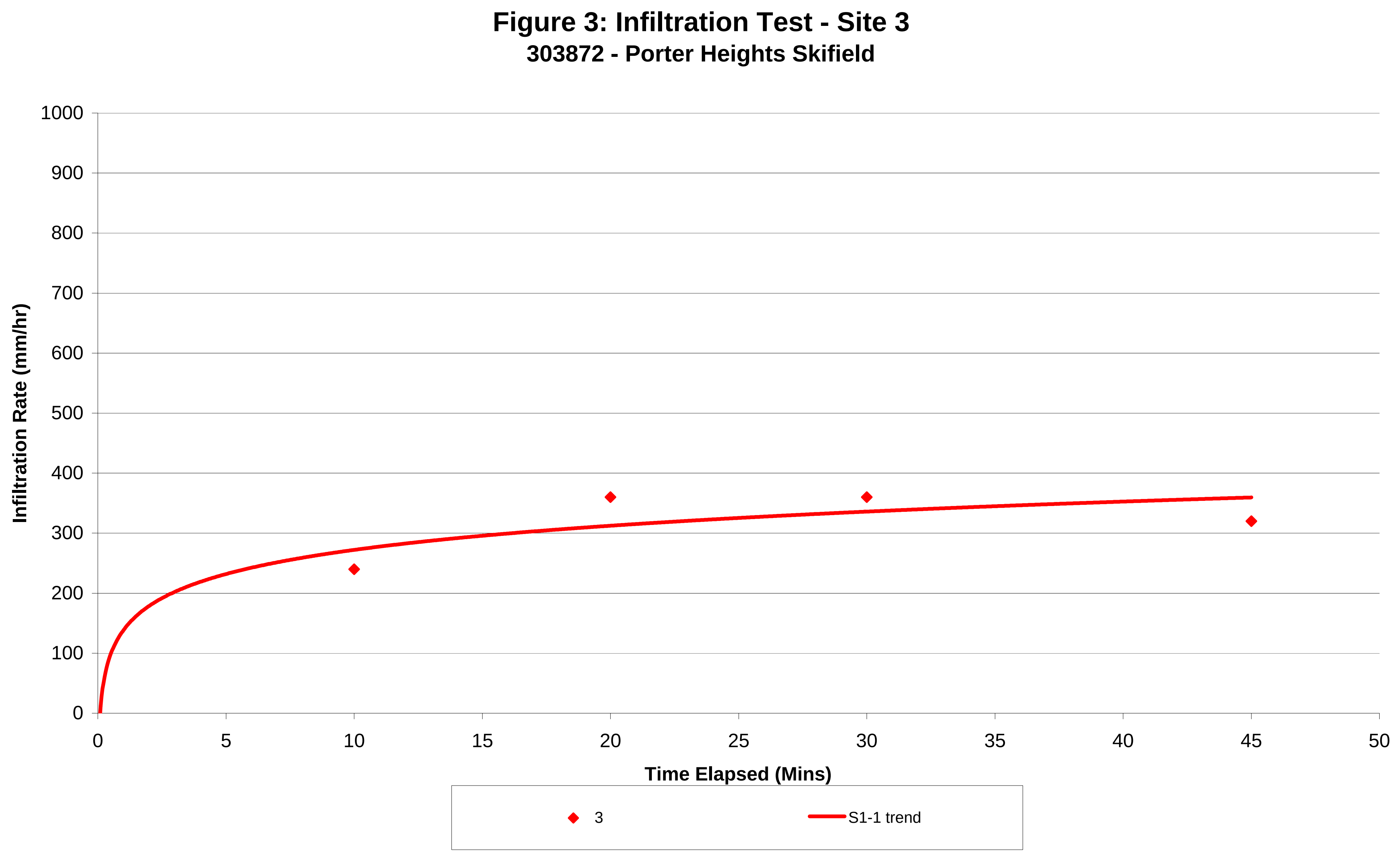


Figure 3: Infiltration Test - Site 3
303872 - Porter Heights Skifield
Infiltration Rate (mm/hr)
1000
900
800
700
600
500
400
300
200
100
0
0
5
10
15
20
25
30
35
40
45
50
Time Elapsed (Mins)
3
S1-1 trend

Infiltration/Percolation Test Results

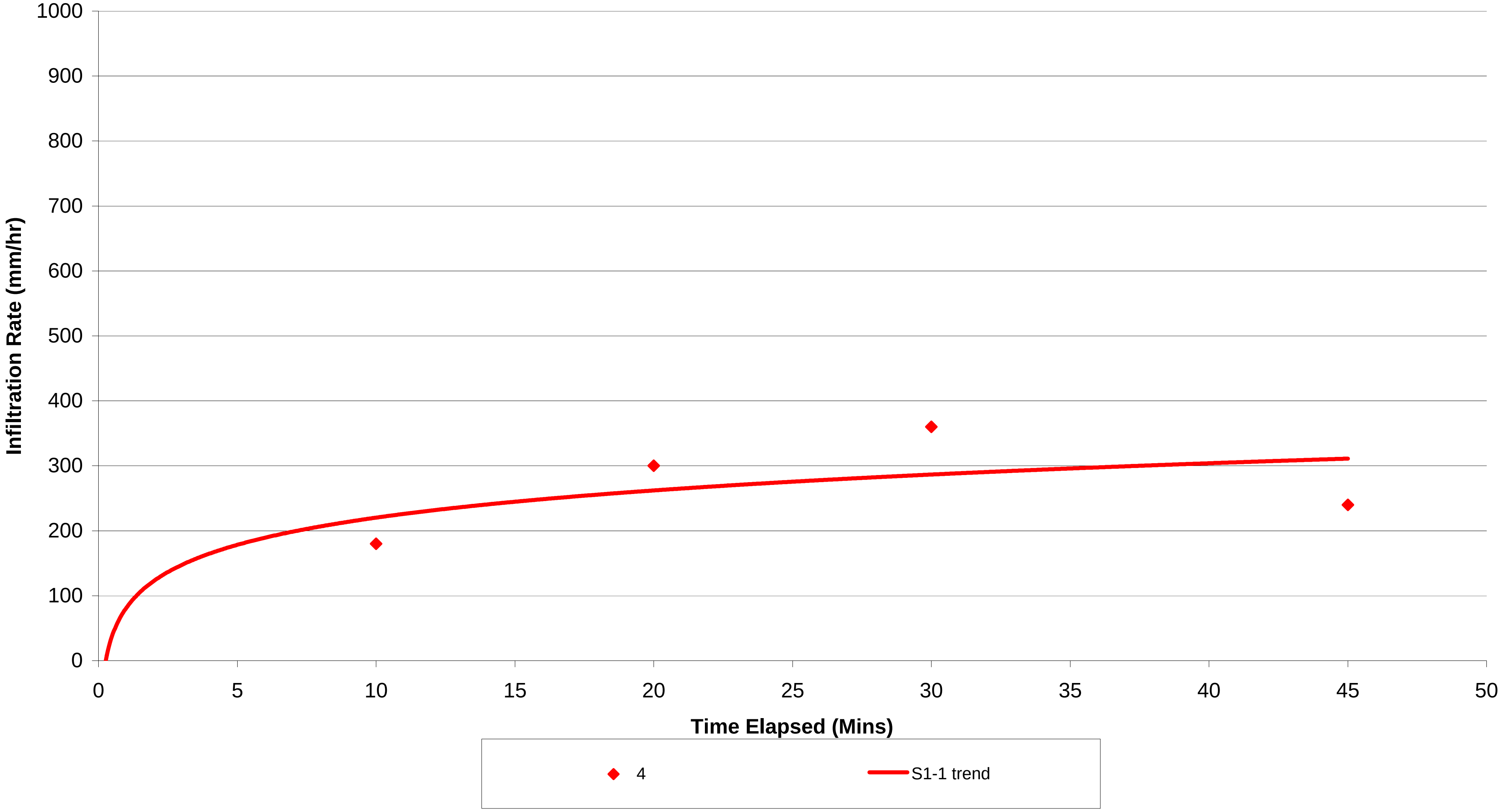
Duffill Watts Consulting Group

Job Number: 303872
Site: 3
Date: 23/02/2008
Method: Falling Head Infiltration Test
Convert: n
Easting 2401532
Northing 5769281

Time (24 hr)	Depth (mm)	Rise/fall conversion	t change (mins)	Accum t (mins)	d change (mm)	d/m (mm/hr)	Notes
9:00	320	-320		0			
9:10	280	-280	10	10	40	240	
9:20	220	-220	10	20	60	360	
9:30	160	-160	10	30	60	360	
9:45	80	-80	15	45	80	320	

Figure 4: Infiltration Test - Site 4

303872 - Porter Heights Skifield



Infiltration/Percolation Test Results

Duffill Watts Consulting Group

Job Number: 303872
Site: 4
Date: 23/02/2008
Method: Falling Head Infiltration Test
Convert: n
Easting 2401532
Northing 5769281

Time (24 hr)	Depth (mm)	Rise/fall conversion	t change (mins)	Accum t (mins)	d change (mm)	d/m (mm/hr)	Notes
9:00	270	-270		0			
9:10	240	-240	10	10	30	180	
9:20	190	-190	10	20	50	300	
9:30	130	-130	10	30	60	360	
9:45	70	-70	15	45	60	240	