R E P O R T

Geotechnical Inspection
Reach 8 Chainage 400-500m
Henderson Creek, Waitakere City

Prepared for

EcoWater Solutions
Waitakere's Three Waters

Private Bag 93109
Henderson

28 July 2005

42088696/R023

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Contents

URS New Zealand Ltd (URS) has undertaken a geotechnical investigation on a section of Opanuku streambank, designated as Reach 8 Chainage (Ch) 400-500m Henderson Creek[1]. This section is on the true left hand or western side of Opanuku Stream, between 30m and 130m downstream of Sel Peacock Drive, Lincoln (Figure 1). Broad scale hazard mapping undertaken by URS in 2004 had identified this area as having an elevated risk of streambank instability.

This reach is one of many within Henderson Valley proposed for riparian replanting as part of Project Twin Streams. EcoWater has commissioned URS to undertake a detailed inspection of the streambank in order to identify any potential geotechnical issues that may need to be addressed during execution of the replanting programme.

The work was undertaken as part of the Project Twin Streams Geotechnical Advice and Monitoring Contract (EW 02 497P) and consisted of the following tasks:

- A desktop study of available geological information;
- A detailed inspection of the streambank within the identified chainages;
- The excavation of one hand auger borehole; and
- The preparation of a geotechnical report.

A site inspection was undertaken on 22 June 2005.

[1] This section of streambank is one of 13 reaches designated by EcoWater as forming Henderson Creek. Reach 8 is one of three reaches actually located on the Opanuku Stream immediately upstream of its confluence with Henderson Creek.

2.1 Description

The streambank at this location consists of a generally flat to moderately dipping (< 30^o) slope, although the 1m to 2m high stream scarp is steep (60^o) to sub-vertical. The slope is primarily grass covered, although a variety of shrubs and trees form a line along the stream scarp between Ch400 and Ch440m (Figure 2). Undercutting of the slope is limited to the downstream section i.e. Ch 400 (see Figure 2). Rock of the Waitemata Group outcrops within the streambed and lower banks, particularly upstream near the Sel Peacock Drive Bridge (Figure 3). The stream varies significantly in width, from approximately 5m to 20m.

The presence of a damaged retaining wall structure at Ch450 placed this site within the high hazard category in the URS 2004 study. This wooden retaining wall is in a poor state of repair and exhibits significant outwards bending and tilting (Figure 4). The nearest other structure is a building located approximately 10m back from the top of the streambank.

2.2 Geology

The Opanuku Stream is located within the Henderson Valley, which is a broad and shallow feature eroded into the sandstones and mudstones of the Waitemata Group. The valley has been partially in filled by Holocene and Pliocene-Pleistocene-aged alluvial sediments of the Tauranga Group. The geology of Reach 8 Ch 400-500m is mapped as being alluvial sediments (Puketoka Formation) within a central outcrop of the underlying Waitemata Group (Kermode, 1992). Exposures of Waitemata Group rock were observed on the streambed near Sel Peacock Drive bridge (see Figure 3). The bedding dipped gently (5^o to 10^0 towards the east (i.e. towards the stream).

2.3 Geotechnical Conditions

The geotechnical conditions were established by the following in-situ testing:

- One hand auger borehole located above the retaining wall at approximately Ch455;
- Undrained shear strength (S_u) tests undertaken at 300mm depth intervals within the hole; and
- A Scala penetrometer test undertaken immediately adjacent to the auger hole.

The auger hole and Scala test terminated at depths of 2.0m and 2.1m respectively, due to effective penetration refusal. A borehole layout plan (Figure A1), borehole log (BH1) Scala profile (SP1) and cross-section (Figure A2) are presented in Appendix A. A summary of the soils exposed within the eroded channel is presented in Table 1.

The investigation indicates that the streambank comprises topsoil overlying approximately 2m of firm silty clay and clayey silt with a variable sand content. These materials are believed to be of alluvial origin (i.e. Puketoka Formation). Undrained shear strengths measured within the borehole ranged from 30kPa to

45 kPa. Penetration refusal was inferred to represent the top of the Waitemata Group rock. The very rapid transition from alluvial soil to rock indicates that erosion had removed the residual soil developed on top of the Waitemata Group prior to the deposition of the Puketoka Formation.

Groundwater table in borehole BH1 was encountered at 1.9m deep at the end of drilling on 22 June 2005, which approximately coincides with the stream water level at the time of site investigation.

3.1 Slope Stability

Deformation within the existing retaining wall indicates that the streambank is failing, albeit slowly. No other areas of instability were noted, apart from some undercutting of the streambank soils near the waterline. Long-term stability of the retained slope will require the replacement of the existing structure, preferably with one founded in the underlying Waitemata Group rocks. It is expected that without replacement, the existing retaining wall will fail. Although this will not represent any direct hazard to adjacent structures, it will result in ongoing deposition of sediment into the stream.

The more widespread undercutting of the lower streambank during periods of high water flows can be adequately addressed by the planting of appropriate flora species such Rautahi, Purei, Sedge and Flax. This will help hold the soil together, trap sediment and reduce the velocity of water immediately adjacent to the stream bank.

3.2 Replanting Programme

Replanting of this area should focus on the protection of the lower banks from high water flows, as this is the best means of ensuring long-term streambank stability. Tree stumps and other significant root systems should be retained in place during vegetation clearance in order to reduce the potential for replanting initiating further slope instability. In addition, any significant areas of exposed soil should be protected by a suitable vegetative matting or straw cover until replacement plants become established.

Kermode, L.O., 1992. Geology of the Auckland Urban Area. Scale 1:50,000. Institute of Geological and Nuclear Sciences Geological Map 2, Sheet R11

URS, 2004. Project Twin Streams, Geotechnical Evaluation of the Henderson Creek Corridor.

Limitations

SECTION 5

URS New Zealand Ltd (URS) has prepared this report for the use of EcoWater in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in Contract EW 02 497P and our correspondence dated 18 April 2005.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report is based on the conditions encountered at the time of site inspection on 22 June 2005. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by inspection, sampling, testing or other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. The borehole logs indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of conditions as constrained by the project budget limitations. Our conclusions are based upon the analytical data presented in this report and our experience.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, URS must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

Whilst to the best of our knowledge information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time. Therefore this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.

FIGURES

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REACH 8 - CHAINAGE 400-500
SITE LOCATION PLAN

FIGURE 1

Figure 2 Upstream view of streambank Reach 8 Ch 400 on the right hand side.

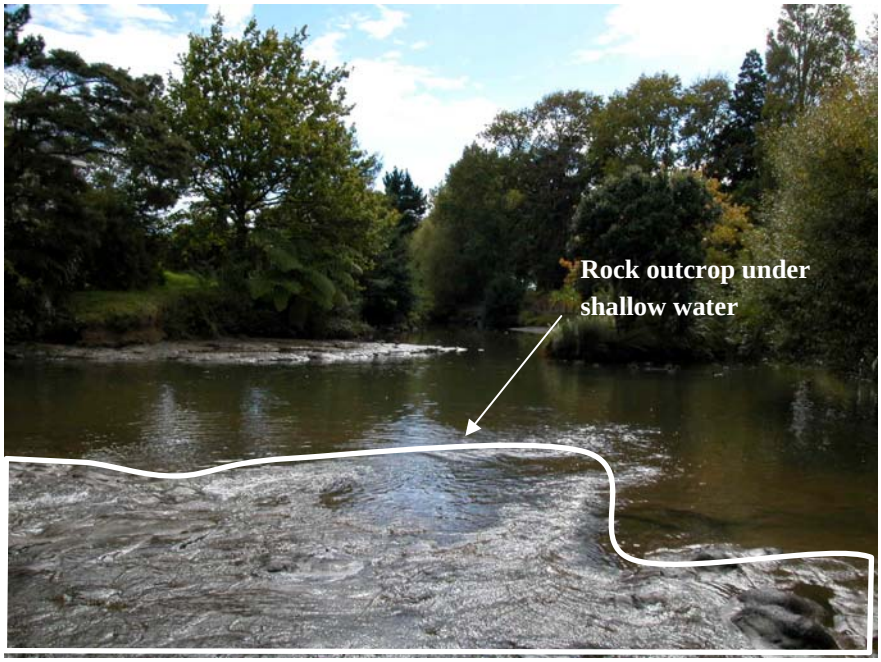
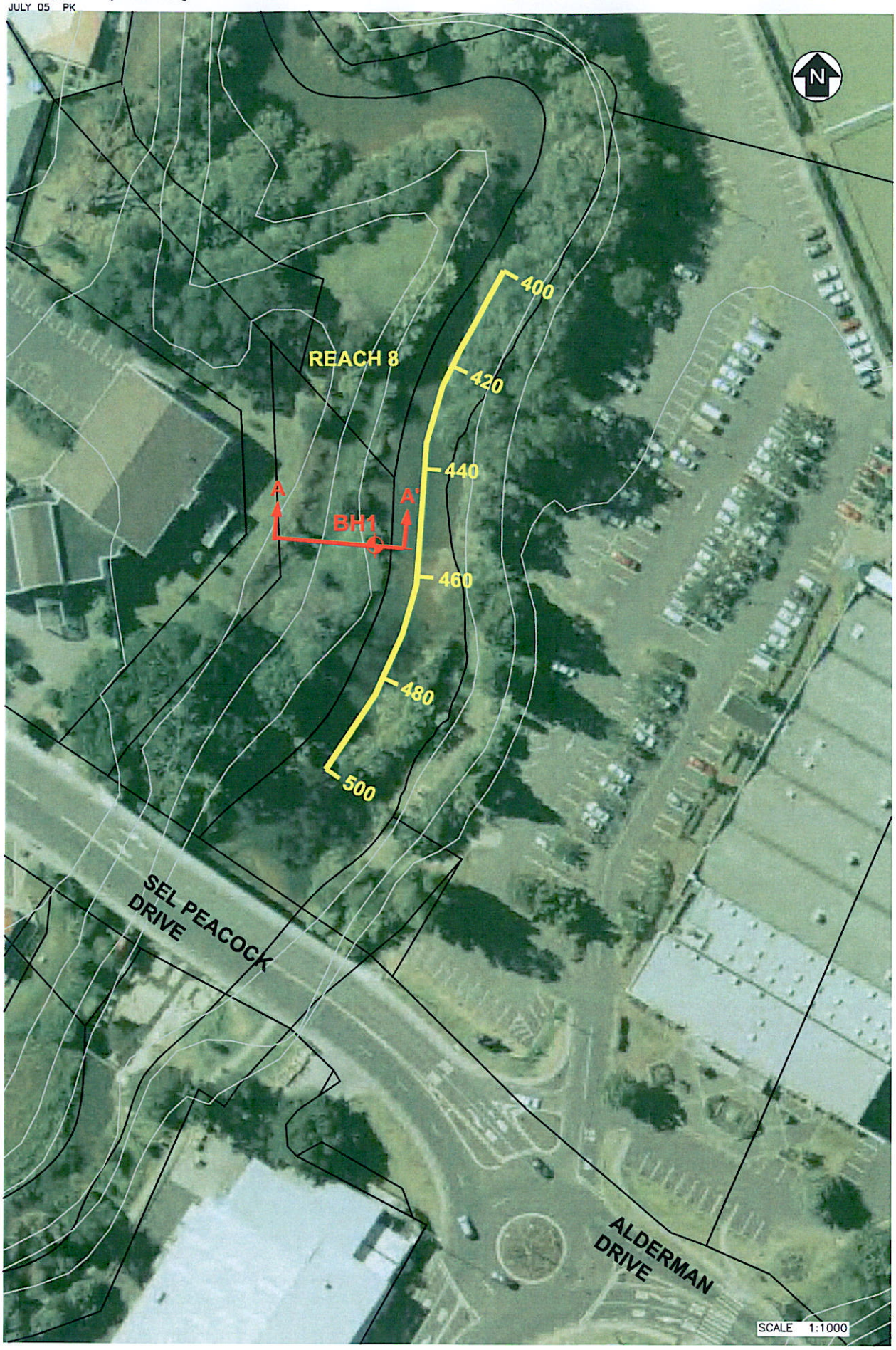


Figure 3 Downstream view of streambank Reach 8 on the left hand side from Sel Peacock Drive bridge. Rock outcrop is under the shallow water.

Figure 4 Old retaining wall on Reach 8 Ch450

APPENDIX A

U:\Jobs\42088696\WA696K01.dwg
JULY 05 PK



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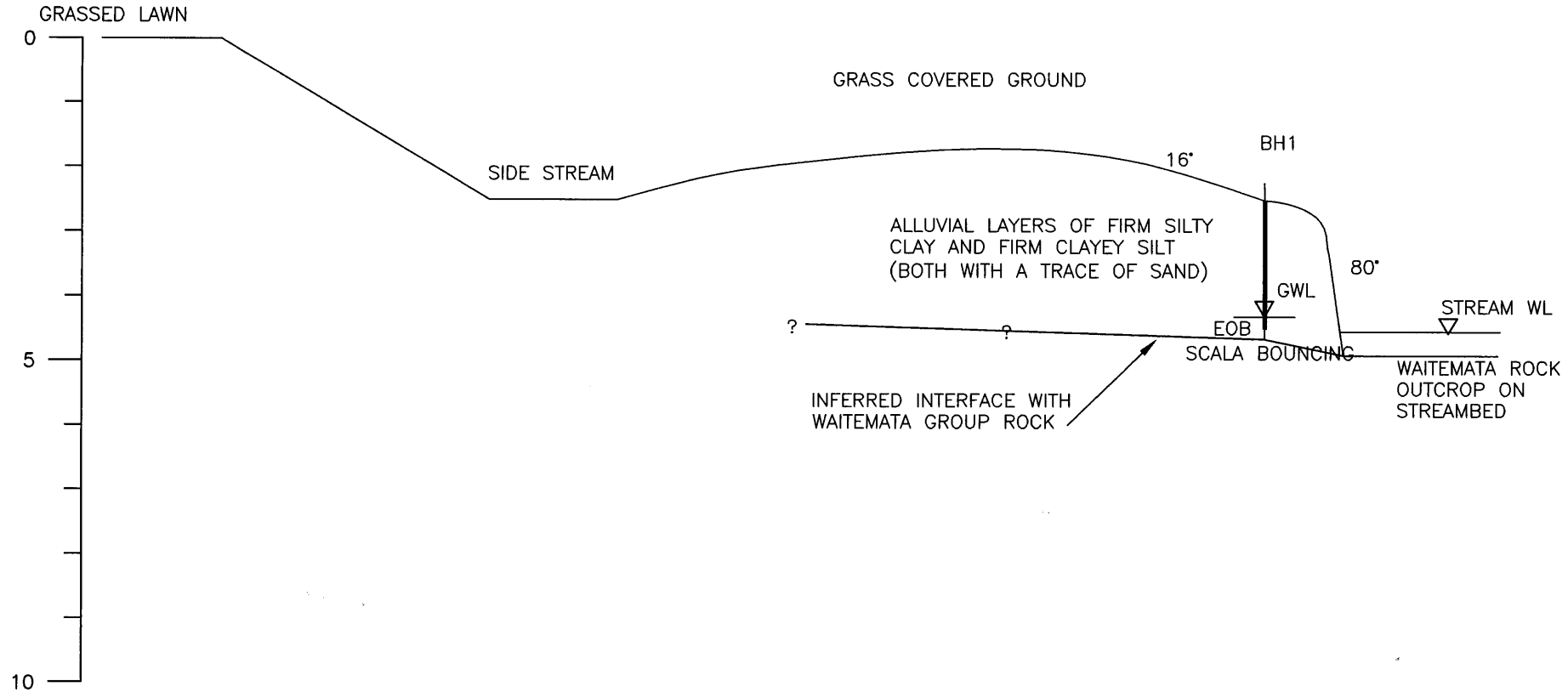
Engineering and Environmental Management

REACH 8 - CHAINAGE 400-500
SITE LAYOUT & BOREHOLE LOCATION

FIGURE A-1

U:\Jobs\42088696\WA696K02_x_section.dwg
20 JULY 05 SCG



Scale 1:100

GEOLOGICAL CROSS SECTION
REACH 8 - CHAINAGE 455

FIGURE A-2

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BOREHOLE LOG

BH1

Drill Method: Hand Auger
Hole Dia: 58 mm
Date Drilled: 22/06/05

Drilled By: DB/MR
Logged By: DB/MR
Checked By: MS

PROJECT NO: F312
PROJECT: Henderson Creek
LOCATION: Henderson

Geology	DRILLING: Method	DRILLING: % Recovery	Depth (m)	Symbols	SOIL/ROCK DESCRIPTION	Depth (m)	Groundwater	Samples	UNDRAINED SHEAR STRENGTH	FIELD TESTS: SPT N Value	FIELD TESTS: Others
			0.0		Ground Surface	0.00			Peak (kPa) 40 80 120 160 200; Residual (kPa) 40 80 120 160 200		
PUKETOKA FORMATION	HAND AUGER	100			TOPSOIL	0.20					
			1.0		CLAY, silty, firm, moist, slightly to moderately plastic, brown speckled orange, with a trace of fine to medium sand Below 1.2 m grey and brown				14 45 15 37 15 35 17 31		
					SILT, very clayey, firm, moist, slightly plastic, grey speckled white, with a trace of fine to coarse sand Below 1.7 m very stiff	1.50	22/06/05		18 46 215		
			2.0		End of Borehole at 2.0 m (too stiff to auger)	2.00					
			3.0								
			4.0								
			5.0								

Remarks: Scala Penetrometer Test (SP1) from 2.00 to 2.15 m

Soil Engineering Ltd

Lithologic Key: Topsoil, Fill, Clay, Silt, Sand, Gravel, Rock, Peat

Sample Key: SPT, Undisturbed Tube, Disturbed, Core

Soil Engineering Ltd
Consulting Geotechnical Engineers

SCALA PENETROMETER TEST — SP1

Project:	Henderson Creek, Henderson	Job No:	F312
Date:	22/06/2005	Remarks:	Carried out in BH1

Depth (m)	Blows/ 50mm	Depth (m)	Blows/ 50mm	Depth (m)	Blows/ 50mm
0.05		3.05		6.05	
0.10		3.10		6.10	
0.15		3.15		6.15	
0.20		3.20		6.20	
0.25		3.25		6.25	
0.30		3.30		6.30	
0.35		3.35		6.35	
0.40		3.40		6.40	
0.45		3.45		6.45	
0.50		3.50		6.50	
0.55		3.55		6.55	
0.60		3.60		6.60	
0.65		3.65		6.65	
0.70		3.70		6.70	
0.75		3.75		6.75	
0.80		3.80		6.80	
0.85		3.85		6.85	
0.90		3.90		6.90	
0.95		3.95		6.95	
1.00		4.00		7.00	
1.05		4.05		7.05	
1.10		4.10		7.10	
1.15		4.15		7.15	
1.20		4.20		7.20	
1.25		4.25		7.25	
1.30		4.30		7.30	
1.35		4.35		7.35	
1.40		4.40		7.40	
1.45		4.45		7.45	
1.50		4.50		7.50	
1.55		4.55		7.55	
1.60		4.60		7.60	
1.65		4.65		7.65	
1.70		4.70		7.70	
1.75		4.75		7.75	
1.80		4.80		7.80	
1.85		4.85		7.85	
1.90		4.90		7.90	
1.95		4.95		7.95	
2.00		5.00		8.00	
2.05	3	5.05		8.05	
2.10	20	5.10		8.10	
2.15	bouncing	5.15		8.15	
2.20		5.20		8.20	
2.25		5.25		8.25	
2.30		5.30		8.30	
2.35		5.35		8.35	
2.40		5.40		8.40	
2.45		5.45		8.45	
2.50		5.50		8.50	
2.55		5.55		8.55	
2.60		5.60		8.60	
2.65		5.65		8.65	
2.70		5.70		8.70	
2.75		5.75		8.75	
2.80		5.80		8.80	
2.85		5.85		8.85	
2.90		5.90		8.90	
2.95		5.95		8.95	
3.00		6.00		9.00