

The River Ilston

An investigation into a River's Changing Characteristics

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Environmental Conservation- year 1

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Introduction 3.0

The Ilston river is part of the Pennard Pill valley, located on the Gower Peninsula in South Wales, a special area of conservation (SAC). Part of the area is also a linear SSSI, designated for its Ash and Alluvial Woodland. (NRW, 2011)

The area encompasses a variety of habitats as it meanders along its 6-mile course. The source of the river is located close to Swansea Airfield and the terrain is mainly marshy grassland with some low-lying shrub and brush, while the mouth of the river, at Three Cliffs Bay, is predominantly Sand dune and Saltmarsh.



Figure 1Location of River Ilston, Gower with 10 Sites marked as red flags (Google Maps, 2015) (Ordnance Survey, 2015)

The geomorphology of the area has a stratigraphically diverse column. "The study catchment (the Ilston basin, Gower) drains a total area of 30 km2. It is underlain by rocks of the Avonian series comprising the south crop of the South Wales coalfield: Millstone Grit, Namurian Shales, Coal Measures and Carboniferous Limestone" (Owen, 1971)

The valley is somewhat unusual in that it was formed by Devensian glacial activity during the regressive phases of the Pleistocene ice age, rather than carved by the river that flows within it. Summer meltwater in Periglacial environments induced the limestone or chalk drainage to become blocked around the edges of ice sheets by permafrost, which effected surface fluvial erosion through runoff (Saunders et al, 1986)

As such, the River Ilston can be considered a misfit stream or more specifically an under fit stream. A stream considerably smaller in dimension than the valley within which it flows. (Emery and Thomas, 1970). The steep sided valleys are dominated by Ash and Ancient Oak woodland, with species such as Field Maple and Sycamore in abundance. Old Beech and Conifer plantations allow Ash saplings to thrive and there is viable Alder regeneration in progress.

There is a complex structure of habitat's supporting a thriving eco system, and with this in mind, special attention was payed to the relationship of ecological form and its behaviour in relation to the physical setting.

The purpose of the study was to investigate the changing characteristics of the River Ilston by evaluating the following hypotheses;

1. The river becomes wider and deeper downstream
2. The cross-sectional area of the river increases downstream
3. The river velocity increases on the outside of a meander
4. The highest velocity is to be found in the centre of the river
5. The river velocity decreases downstream
6. The size of the bedload gets smaller downstream
7. The shape of the bedload becomes more rounded downstream
8. The discharge of water in the river increases downstream



Figure 2 View of River Mouth and 3 Cliffs Bay - Photo credit -- Chris House

Methodology 4.0

In order to gather the relevant data, the river was divided into 10 sites. Starting at the Source, chronologically numbered site 1, the team split into groups of 3/4 people. The following data was collected at each site and recorded for later analysis.



Figure 3 View of river channel – Photo Credit- Natasha R Dodds

Hypotheses 1 and 2

To plot the cross section of each site, a section of river 10m long was marked and divided into 5 equidistant points, using a Tape Measure(TM) and surveying poles. Horizontal readings were taken from water's edge to water's edge to acquire the channel width.

In order to measure the channel depth, measurements were taken at each of the 5 points vertically from water surface to water bed, in 25cm increments across the channel with a Meter Rule (MR). This enabled us to calculate the average width and depth of the river and plot out the cross-section.



Figure 4 Student measuring Depth at source - Photo credit Natasha R Dodds

To determine the cross-sectional area, the total depths were added, in turn, from left bank to right and divided by the amount of measurements taken at each point. This gave the average depth (CM2). To convert this to the cross-sectional area, the average depth was multiplied by the average width giving us our cross-sectional area.

Hypotheses 3

No sites with a meander were studied on this visit and as such no method was required.

Hypotheses 4 and 5

To gather flow velocity data, a 10m stretch of river was measured (TM). A stopwatch was used to time how long a plastic bottle took from starting point (upstream) to end point (downstream). This was repeated 5 times to establish an average and for more accurate analysis. By dividing the distance, the orange travelled, by the time it took, a velocity unit in m/s was calculated. By multiplying this average by 0.85 the surface velocity to was converted into the stream velocity - m/s 3.

A Flowmeter was used at point 7 to take velocity readings at 5 locations of the channel from the Left Bank to Right. One measurement was recorded close to each bank at 25cm depth and a reading was taken in the middle of the river at 3 points. See below diagram for approximate locations of flowmeter. Due to lack of available equipment this was the only site measured via this method.

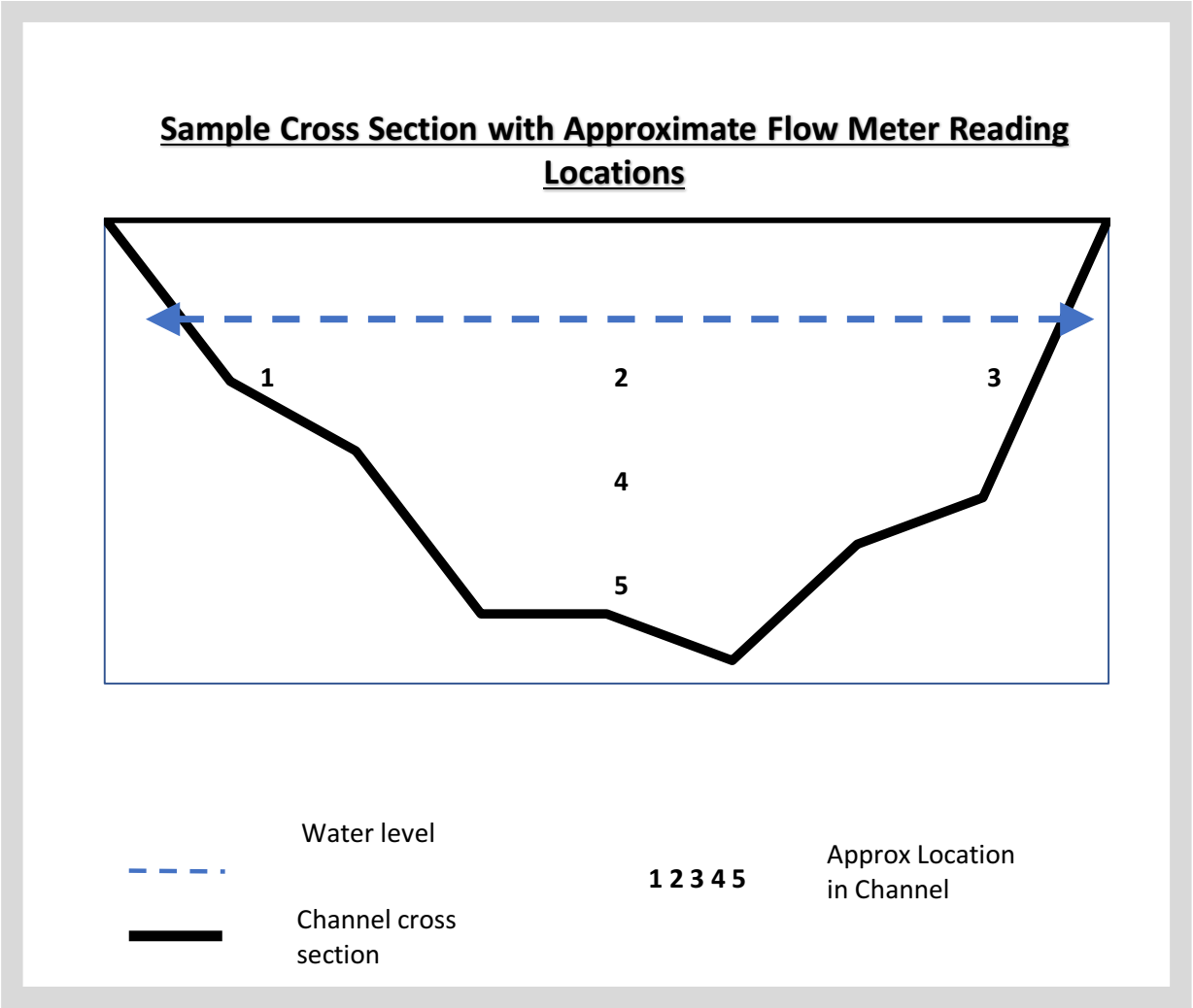


Figure 5 Diagram showing Approx. flow meter locations

Hypotheses 6 and 7

In order to assess the rivers sediment, 5 rock samples were taken from the river bed at each site and using a TM, the long axis was measured to give an average sediment size in cm. The roundness was calculated observationally, using the Powers table of angularity.

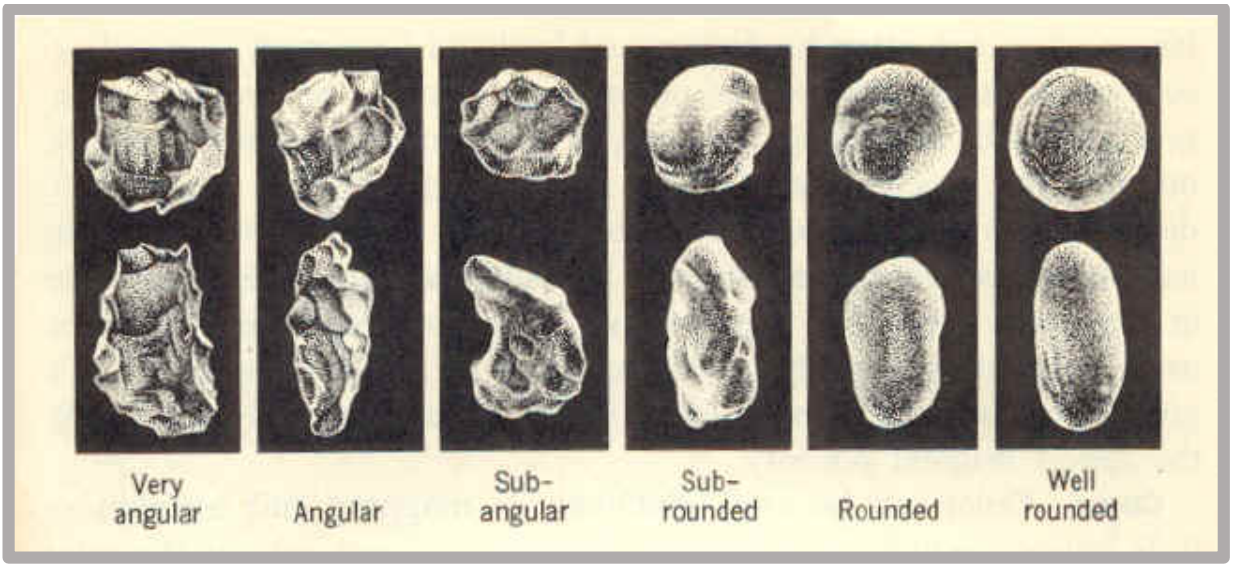


Figure 6 Chart of angularity - Modified after Powers, M. C., 1953, Journal of Sedimentary Petrology, v. 23, p. 118.

Hypothesis 8

To calculate the rivers discharge, the stream velocity was multiplied by the average cross-sectional area giving us the river discharge value or Q in m^3/s.

Results and Analysis 5.0

Hypothesis 1 - The river becomes wider and deeper downstream 5.1

When regarding the data, there appears to be some correlation that the river gets wider downstream, fig 8 highlights a fairly robust scatter with positive linear relationship and a line equation of r2- 0.5. In addition, as indicated by the data, the river follows a pattern of becoming steadily wider downstream, other than Site 3 which can be considered an outlier. This result was expected taking into account the logical fact that the expected volume of water increases as tributaries converge with the flow. When testing this theory statistically, using the Spearman's rank (SR), the result was 0.76, a strong positive correlation.

With Regards to the river getting deeper downstream, there appears to be a negative correlation of -0.4. The deepest site is in fact in the mid-course of the river at 29 cm, with Sites 9 and 10 having the shallowest depths at 2.9cm and 2.1cm respectively. As highlighted in figure 9, there is a non-linear trend with a low r2 line equation of 0.2. This further supports the statistical correlation also suggesting no relationship.

Location	Average Depth (cm)	Average Width (m)
Site 1	13.3	2.36
Site 2	8.82	4.25
Site 3	51.4	5.42
Site 4	17.3	6
Site 5	29.4	6.1
Site 6	4.28	3.83
Site 7	24.42	6.26
Site 8	3.06	6.84
Site 9	2.9	6.1
Site 10	2.1	14.2

Figure 7 Chart showing average width and depth

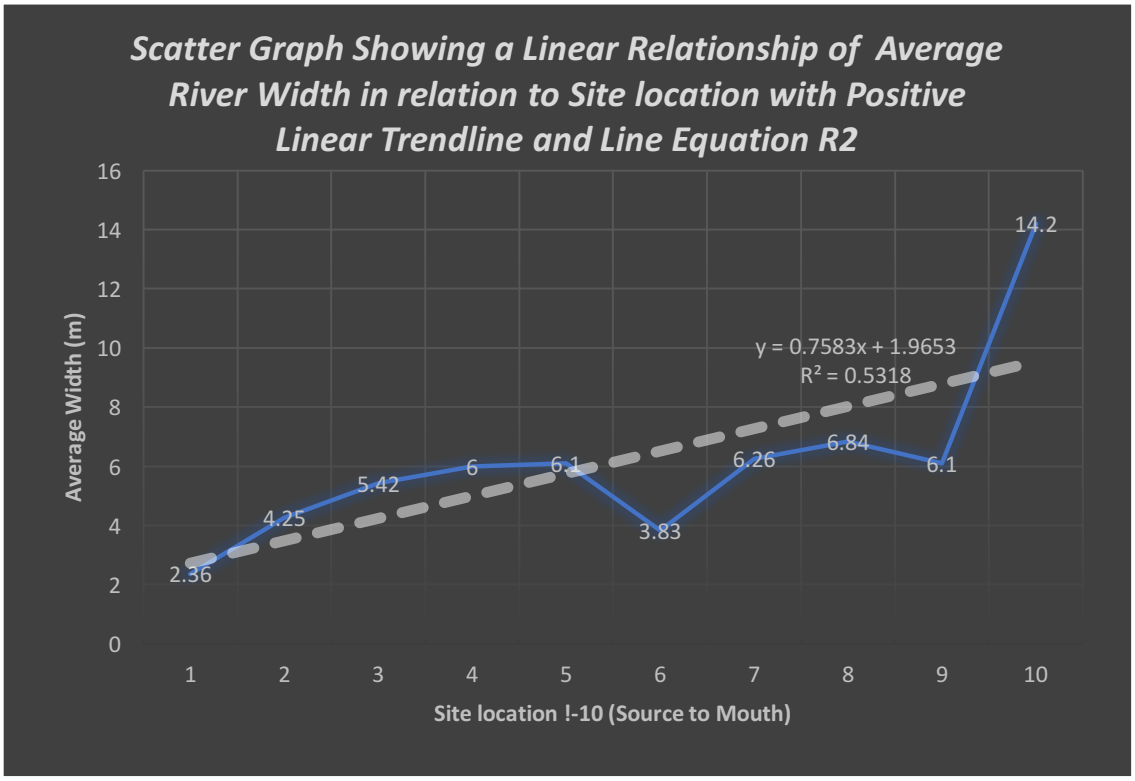


Figure 8 Scatter Graph River Width

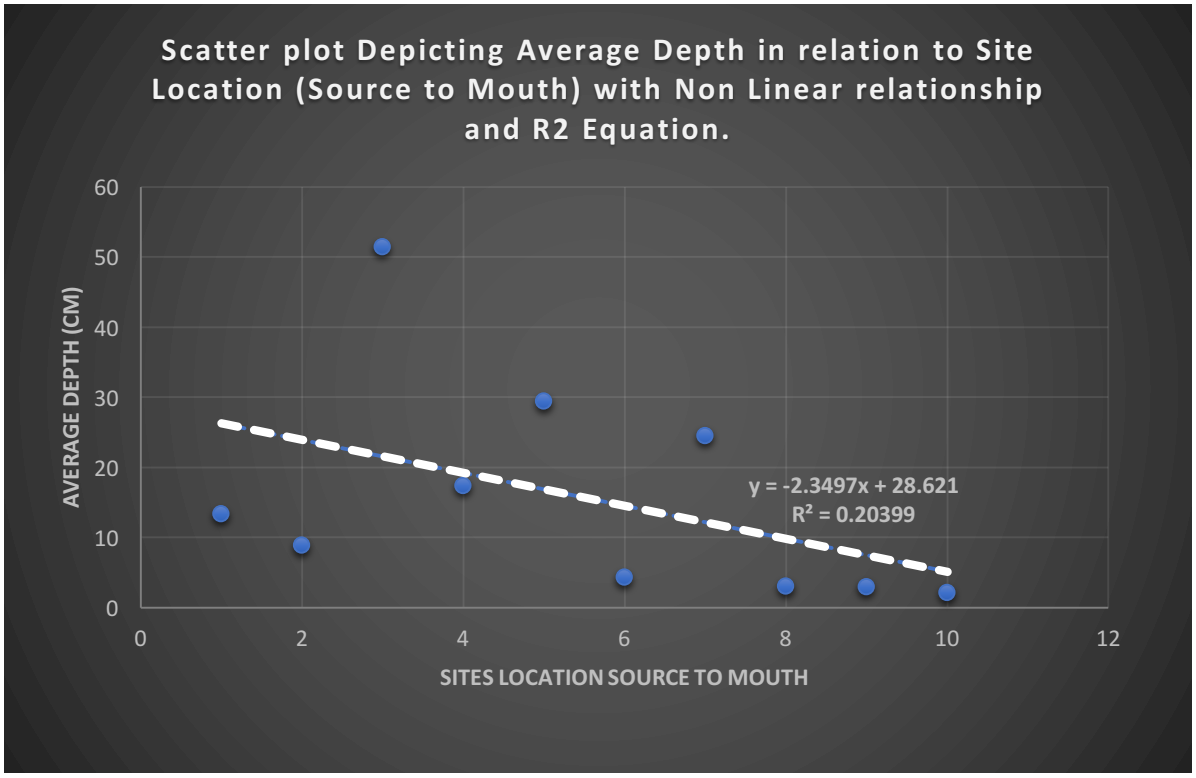


Figure 9 Scatter Graph River Depth

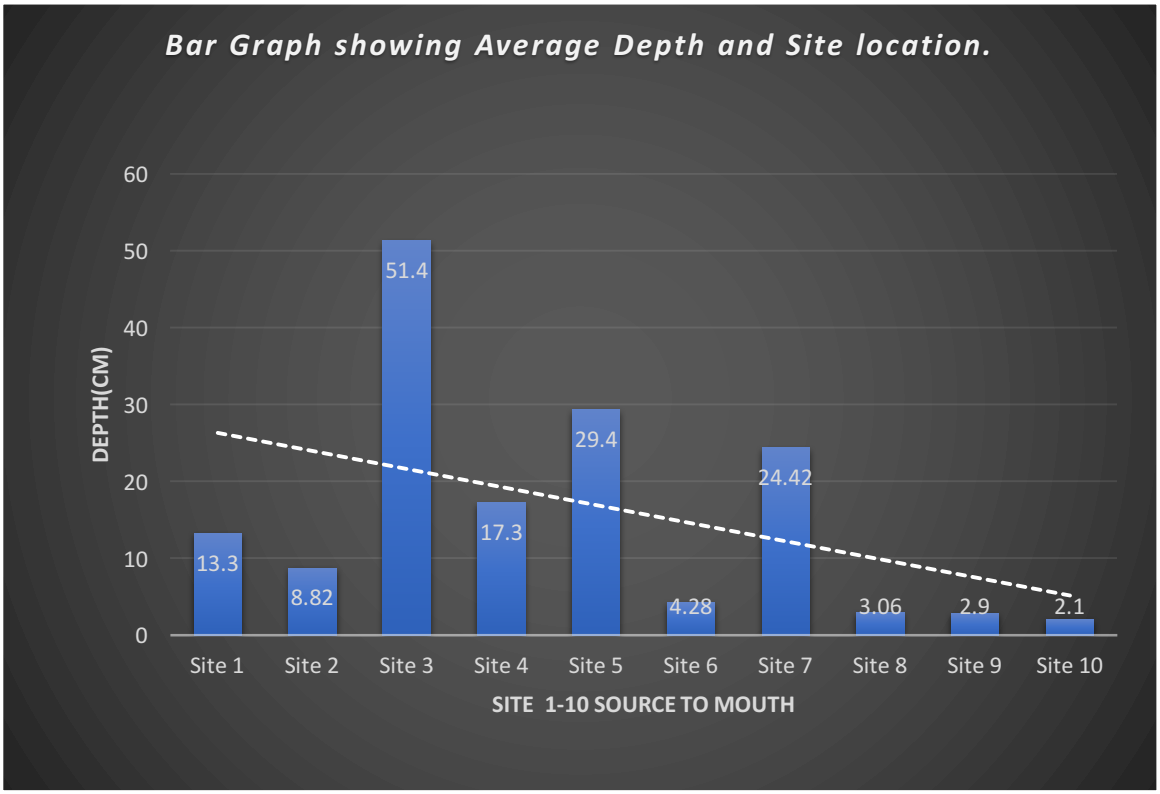


Figure 10 Bar graph showing average depth

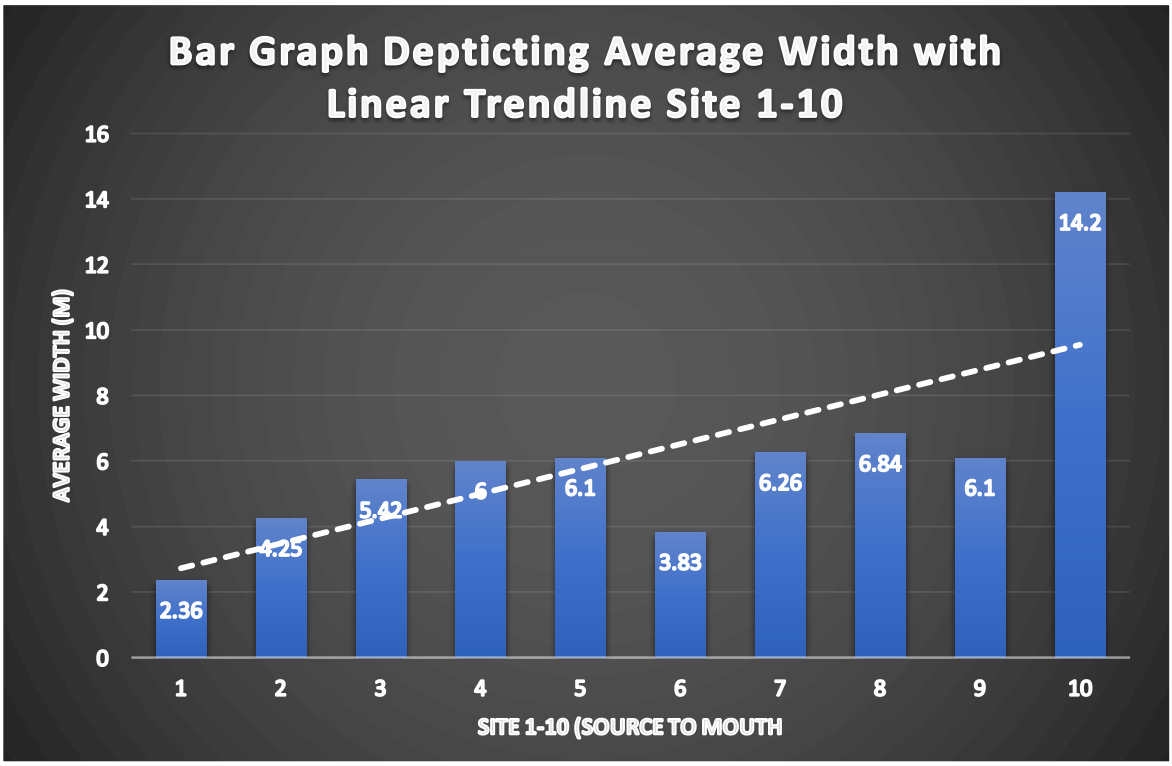


Figure 11 Bar graph showing average width

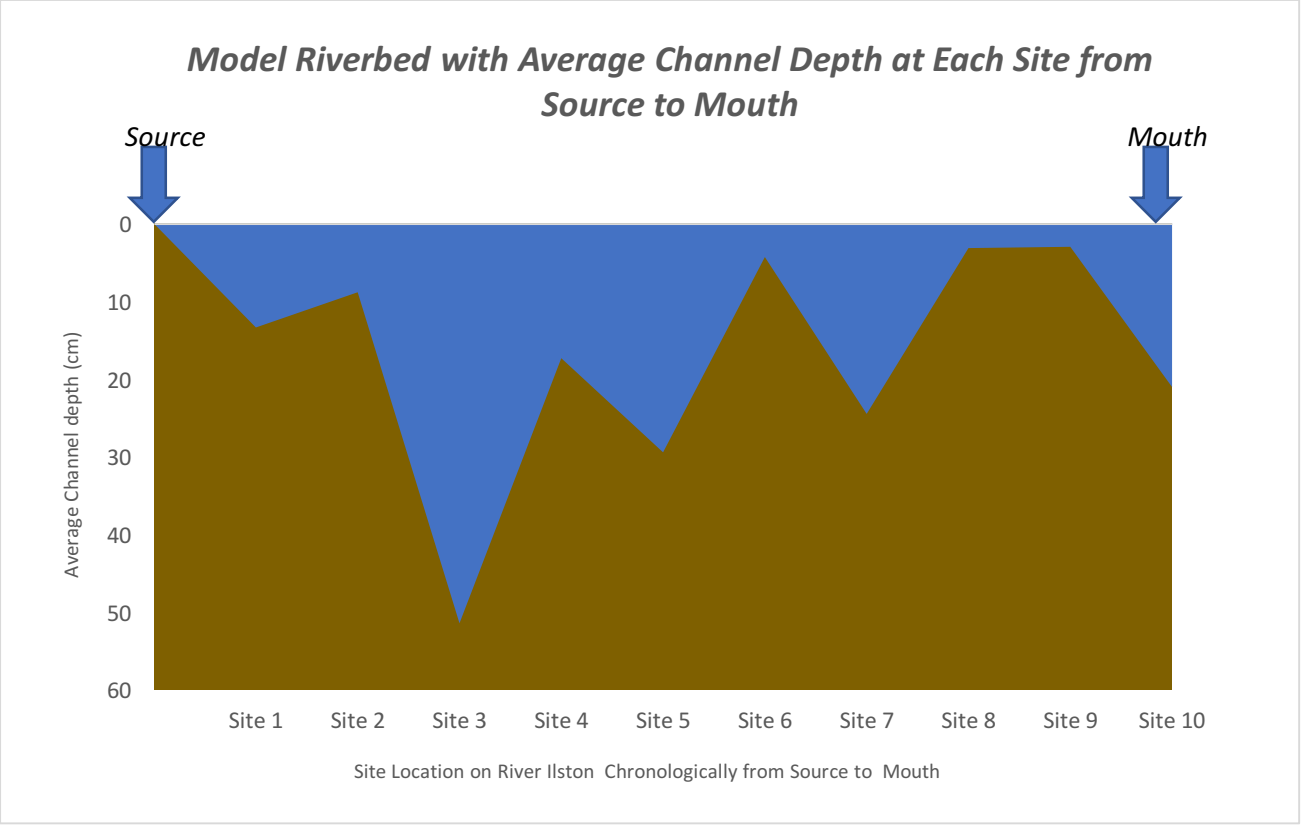


Figure 12 Sample Model showing river depth from source to mouth

Hypotheses 2 – The Cross-sectional area of the river increases downstream 5.2

When considering the Cross-sectional area (CSA), it would appear that the area with the largest CSA was in fact Site 3 (closest to the source), with sites 9 and 10 having a lower average CSA. Site 6 (CSA – 1.7 m2) had the smallest CSA in the study and was quite pointedly smaller than its neighbouring sections site 5 (CSA 17.9) and site 7 (CSA -15.2 m2). This may be due to the stratigraphic composition underlying the river. Water percolates the limestone until it completely saturates all the cracks forming a water table. The climatic process of rain water acidifying the carbon dioxide dissolves the limestone joints further allowing large caverns to form, and so water may flow underground for some distance (Groom, 1950). The scatter was random with a non-linear relationship and an r2 value of 0.06 and the SR statistical test gave a result of -0.24, a weak negative correlation.

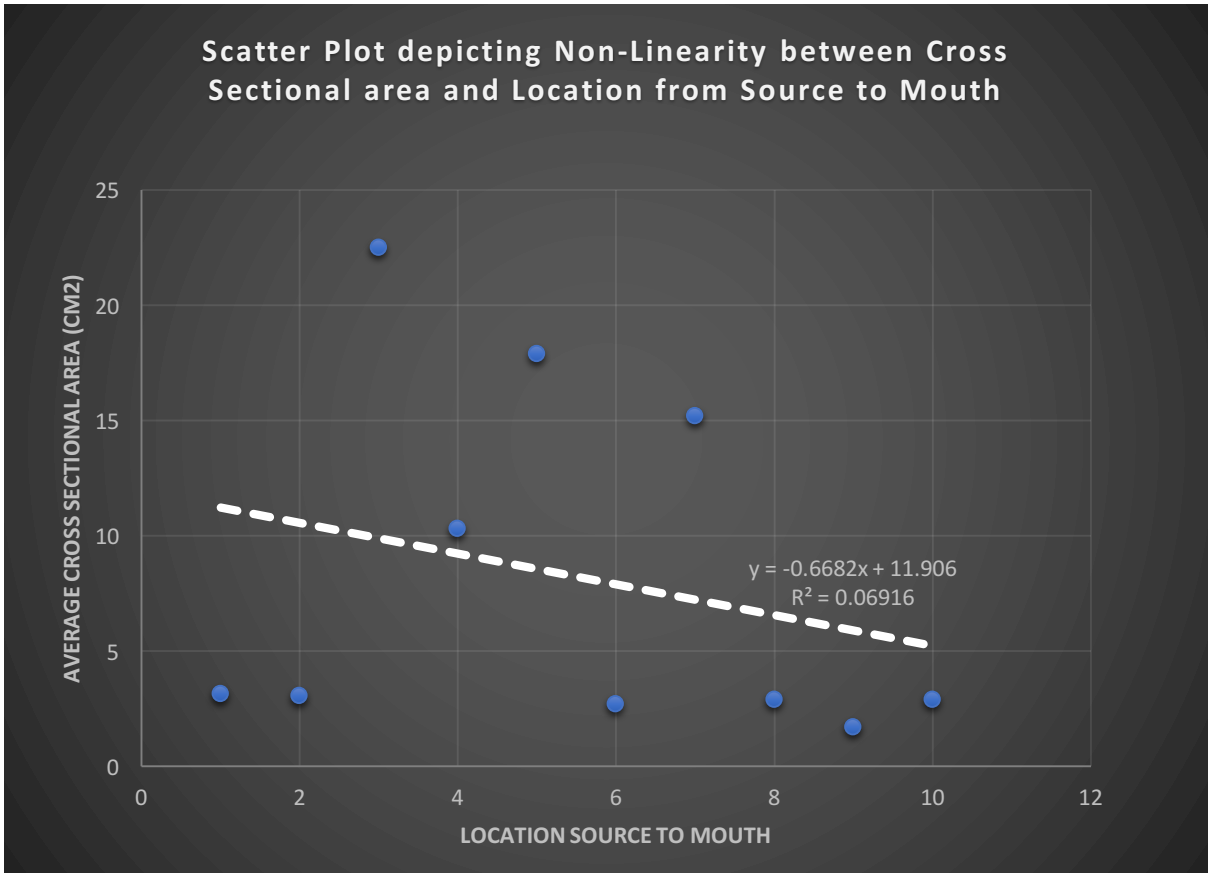


Figure 13 Scatter graph - Cross sectional area

Site Location	point number	Cross Sec Area (cm2)	Average Cross Sec (cm2)	Average (m2)
1	1	32.568		
	2	33.04		
	3	26.668		
	4	31.624		
	5	33.04	31.388	3.14
2	1			
	2	41.225		
	3	40.8		
	4	1.858823529		
	5	38.675	30.63970588	3.07
3	1	7.453874539		
	2	349.048		
	3	275.336		
	4	271.542	225.8449686	22.5
4	1	103.8	103.8	10.3
5	1	179.34	179.34	17.9
6	1	15.86		
	2	43.279		
	3	10.341		
	4	8.809		
	5	9.575	17.5728	1.7
7	1	143.98		
	2	152.744		
	3	148.988		
	4	169.02		
	5	149.614	152.8692	15.2
8	1	26.676		
	2	23.256		
	3	22.572		
	4	19.152		
	5	13.034	20.938	2.9
9	1	17.69	17.69	1.7
10	1	29.82	29.82	2.9

Figure 14 Data Chart CSA

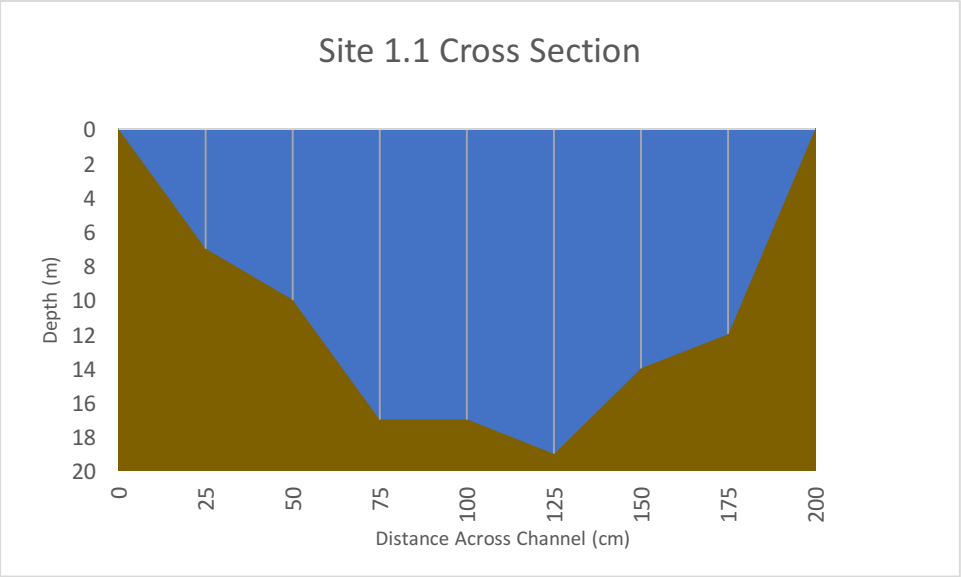


Figure 15 River cross section 1.1

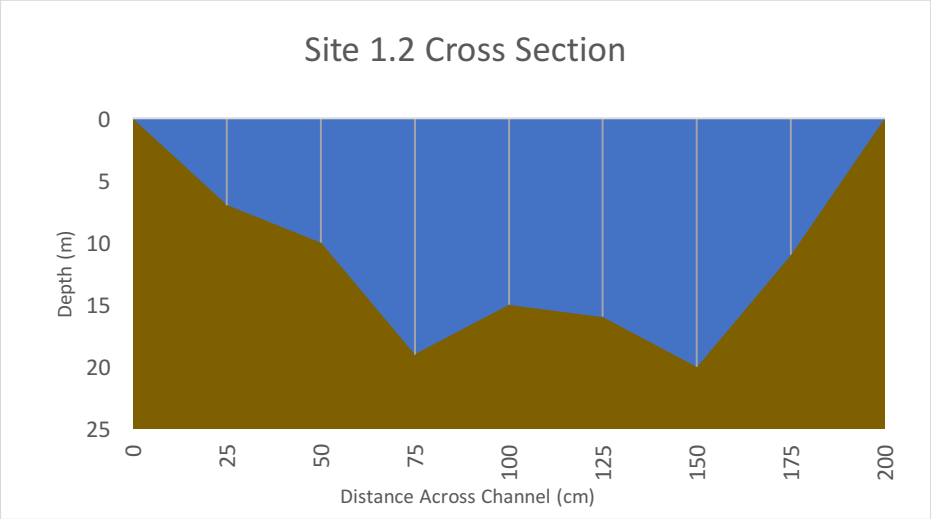


Figure 16 River cross section 1.2

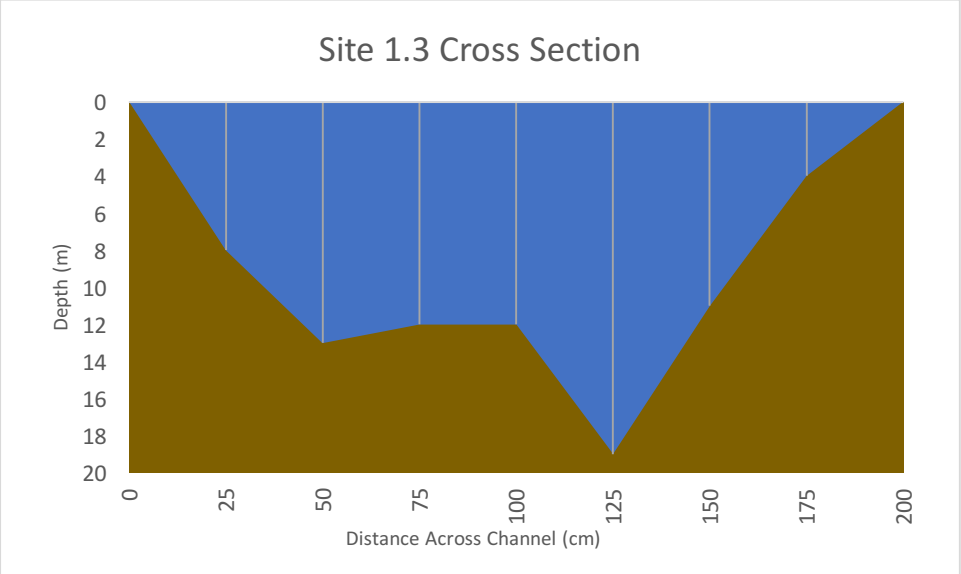


Figure 17 River cross section 1 3

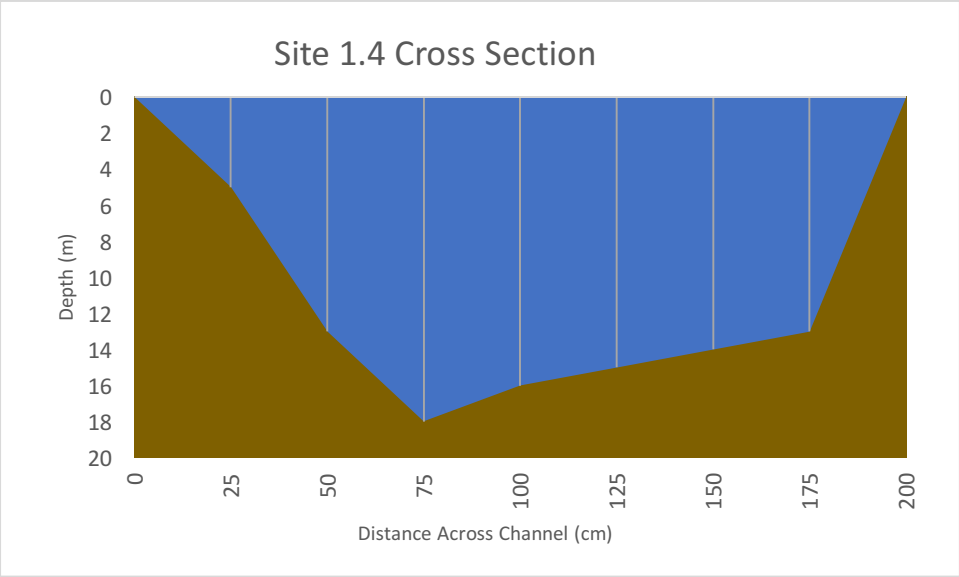


Figure 18 River cross section 1.4

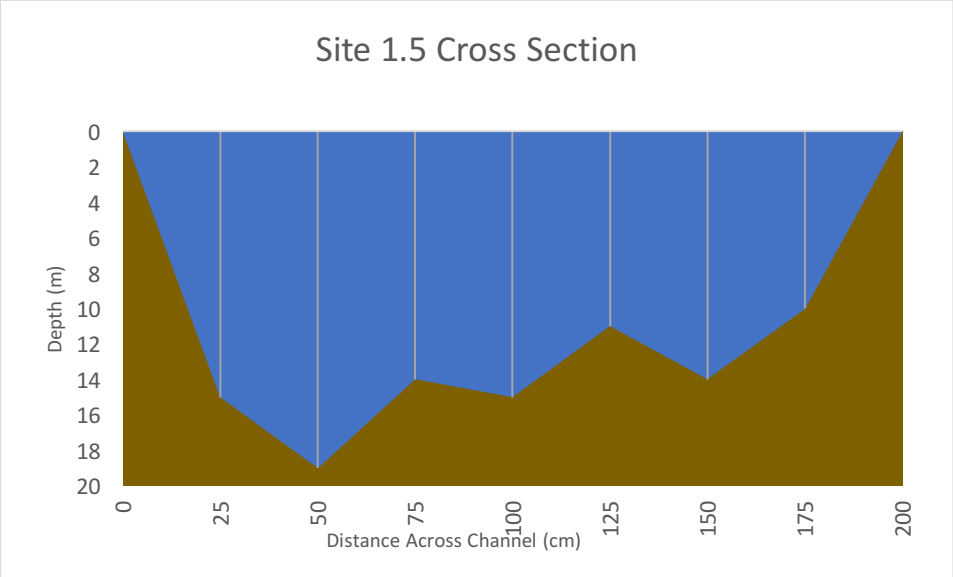


Figure 19 River cross section 1.5

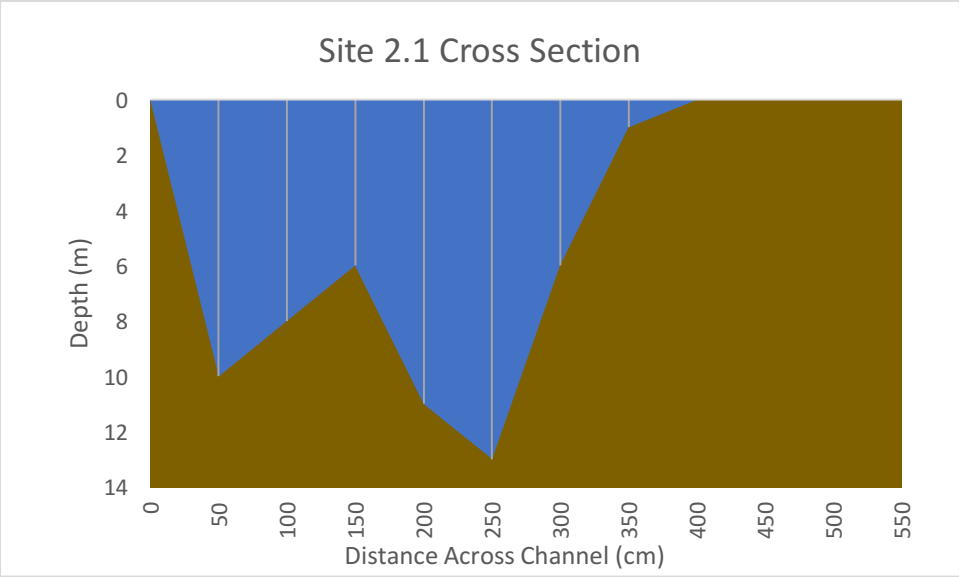


Figure 20 River cross section 2.1

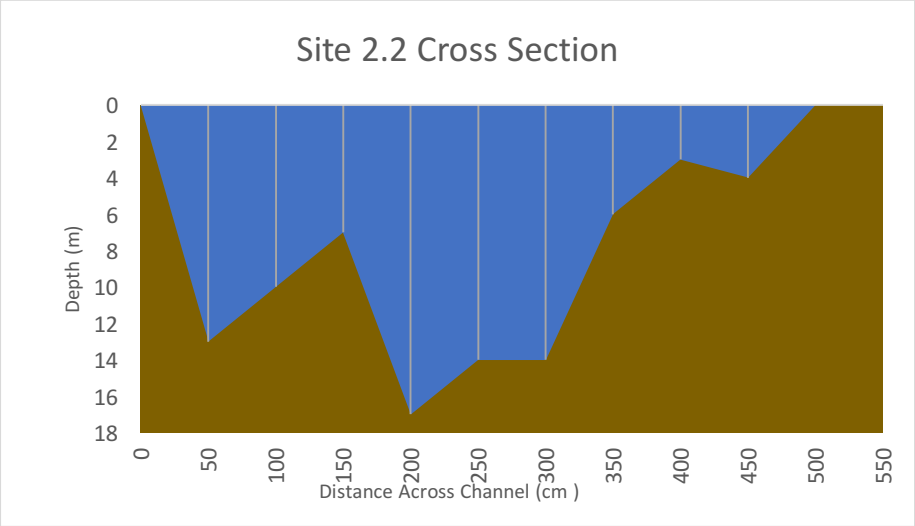


Figure 21 River cross section 2.2

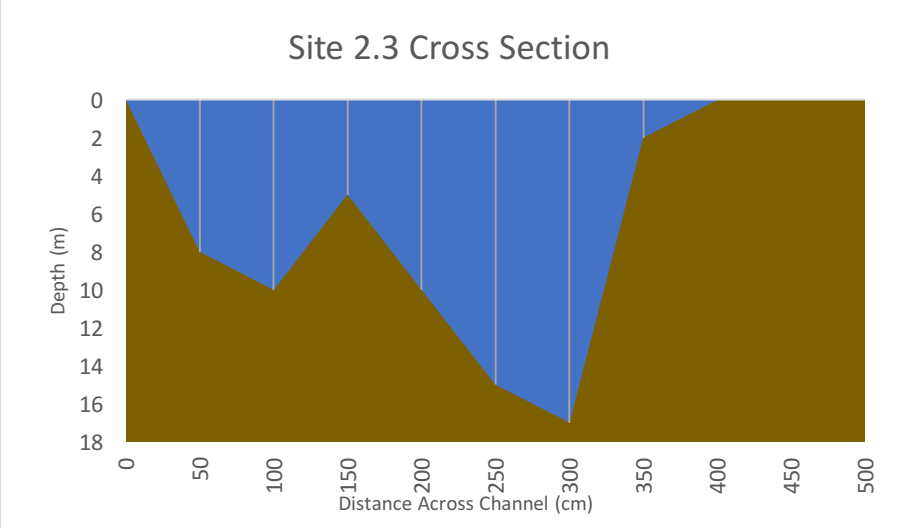


Figure 22 River cross section 2.3

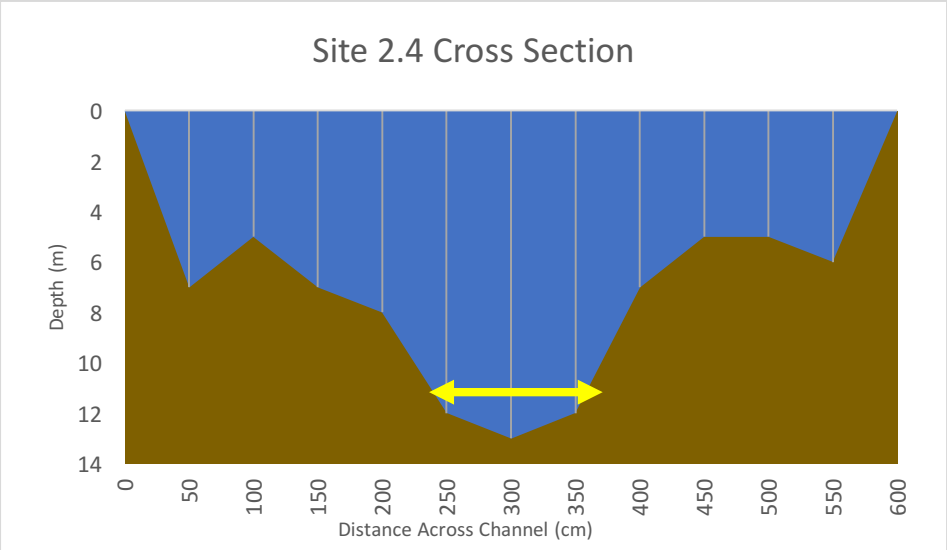


Figure 23 River cross section 2.4

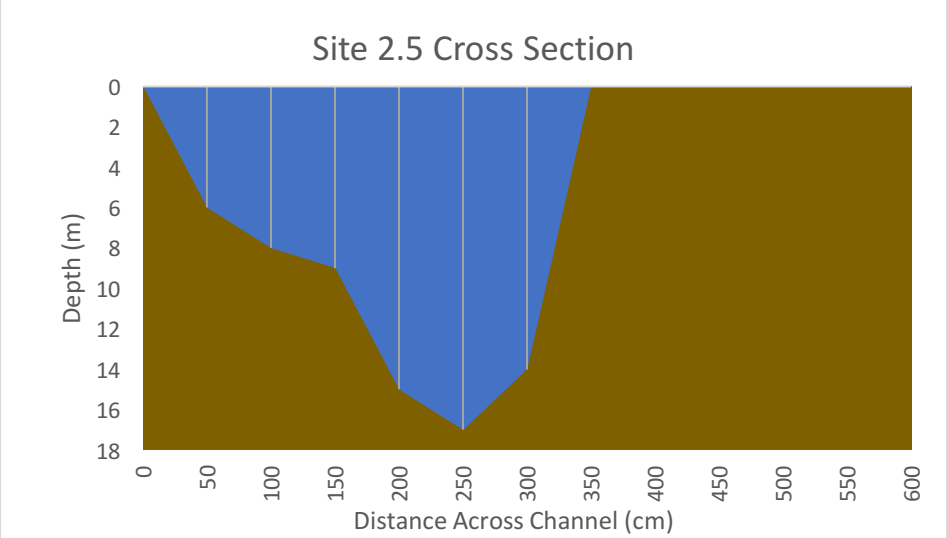


Figure 24 River cross section 2.5

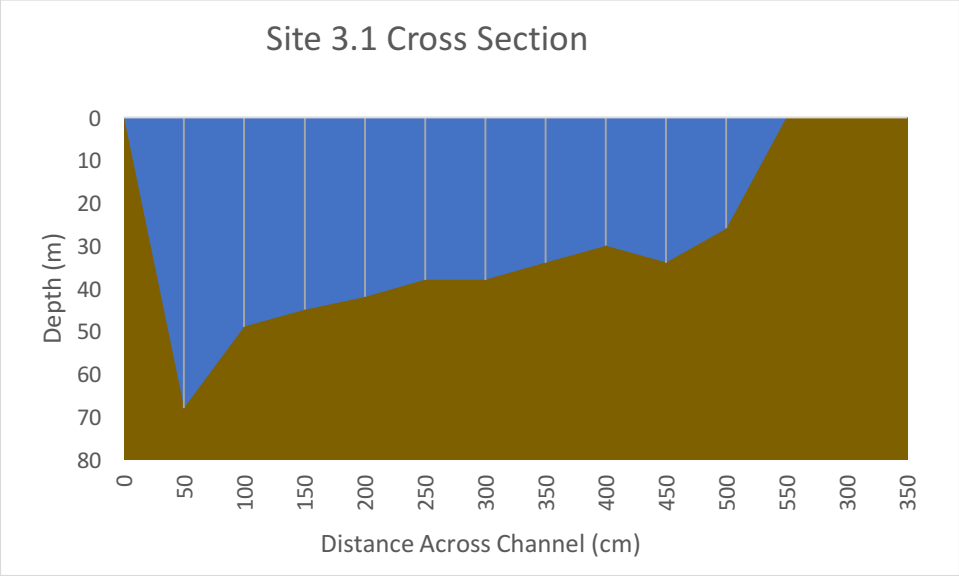


Figure 25 River cross section 3.1

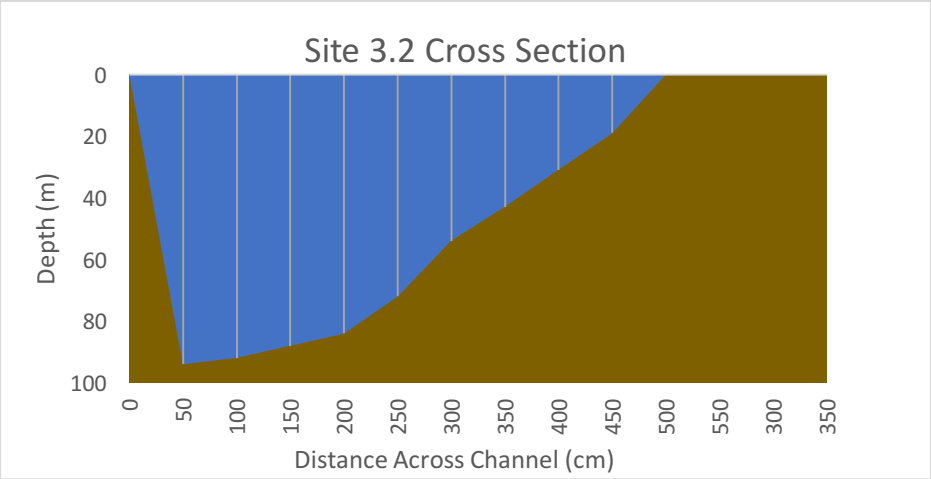


Figure 26 River cross section 3.2

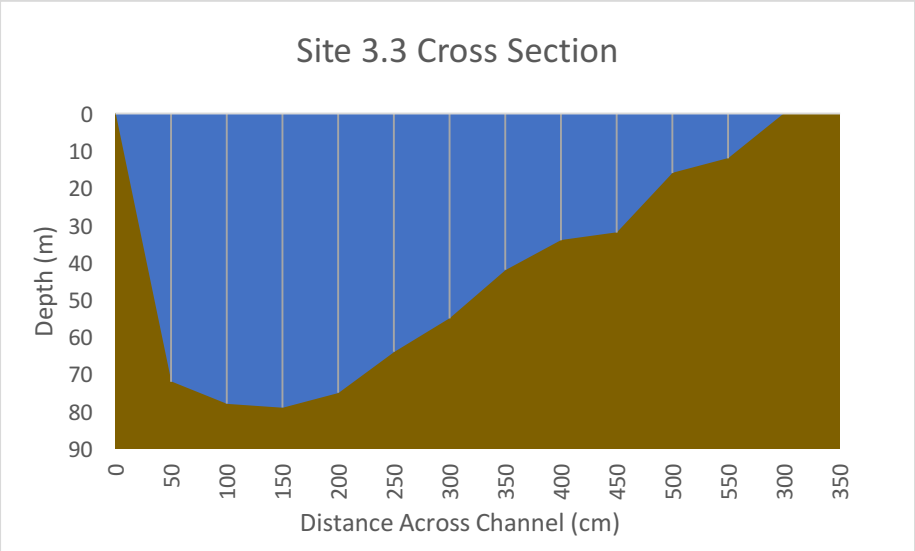


Figure 27 River cross section 3.3

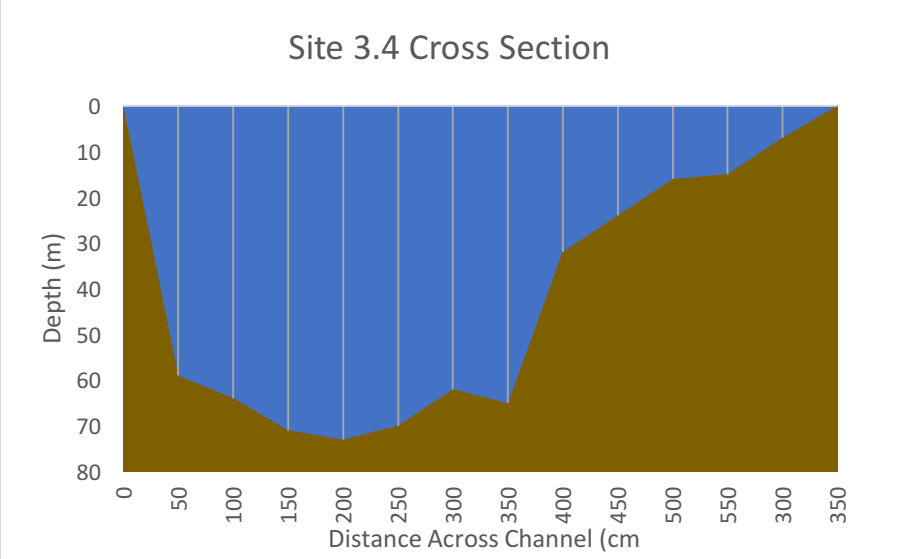


Figure 28 River cross section 3.4

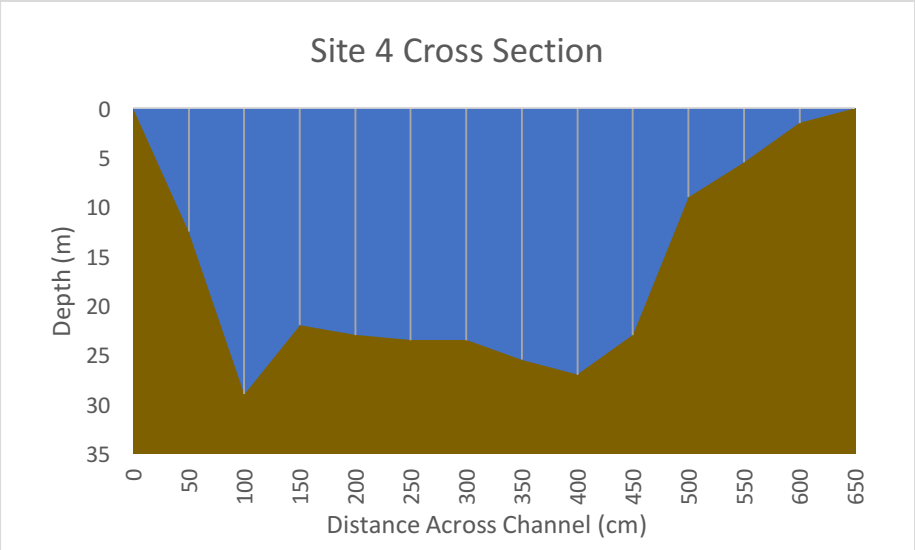


Figure 29 River cross section 4

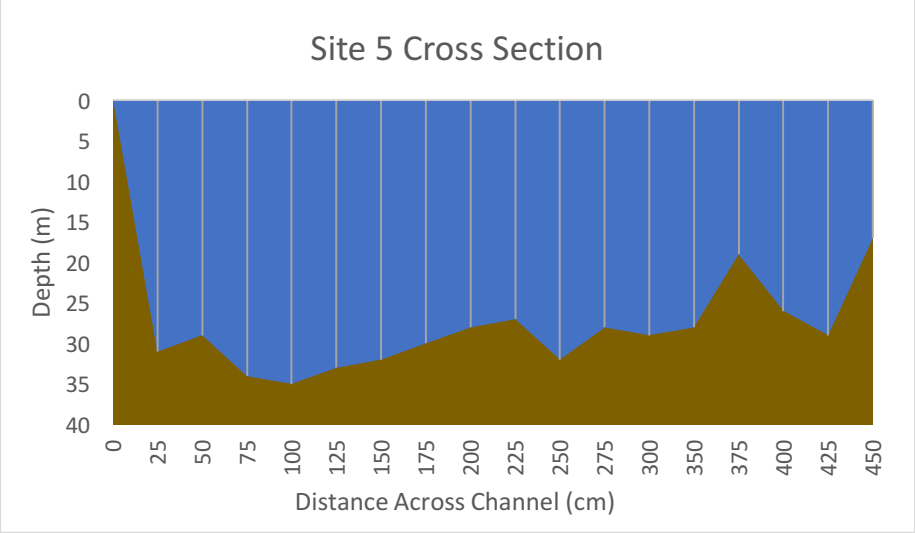


Figure 30 River cross section 5

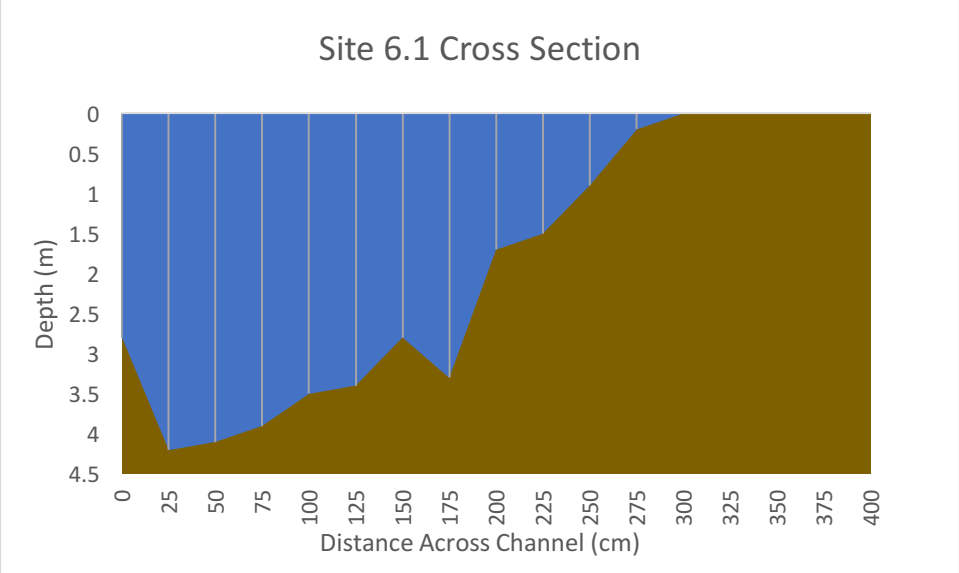


Figure 31 River cross section 6.1

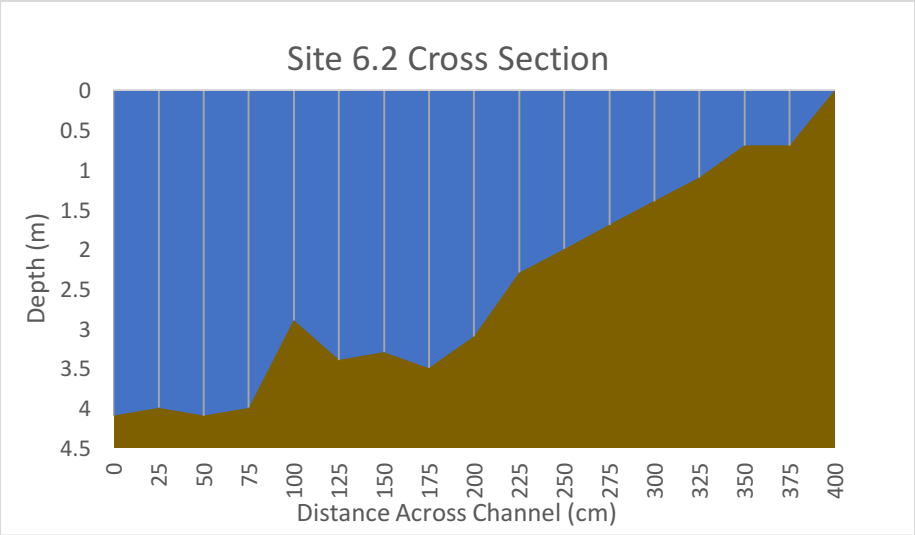


Figure 32 River cross section 6.2

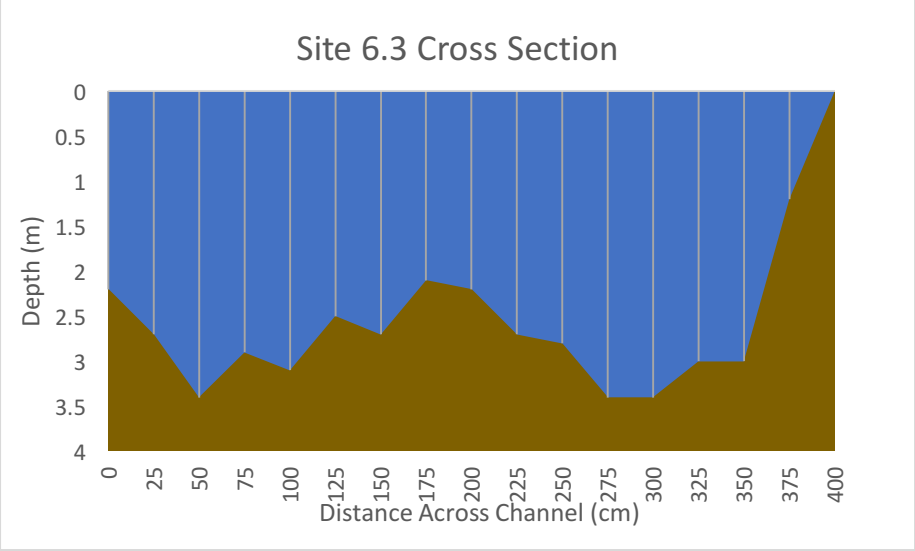


Figure 33 River cross section 6.3

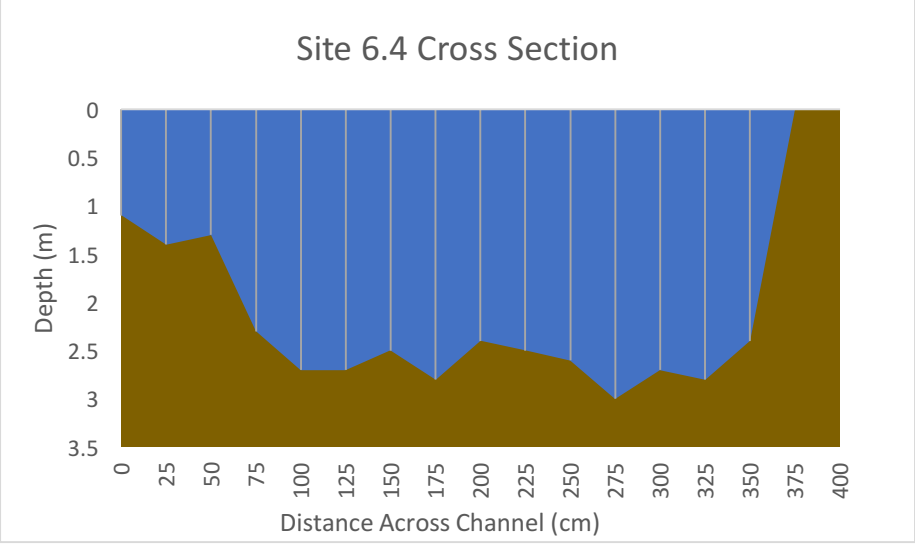


Figure 34 River cross section 6.4

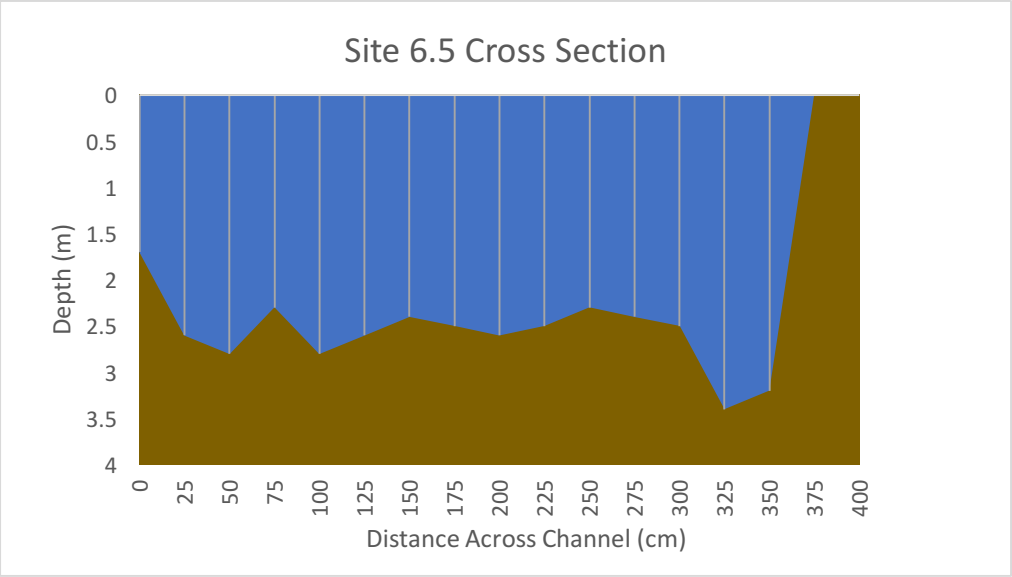


Figure 35 River cross section 6.5

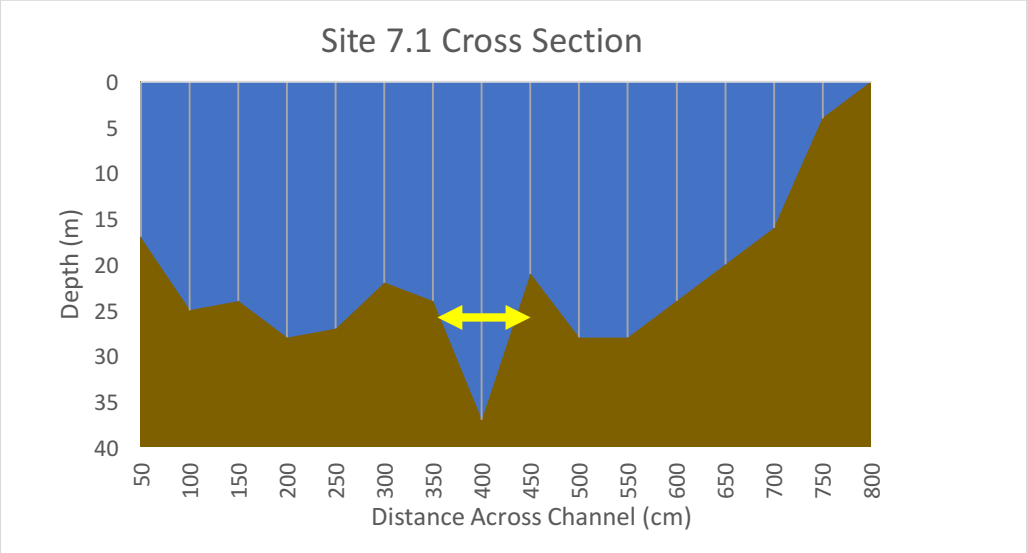


Figure 36 River cross section 7.1

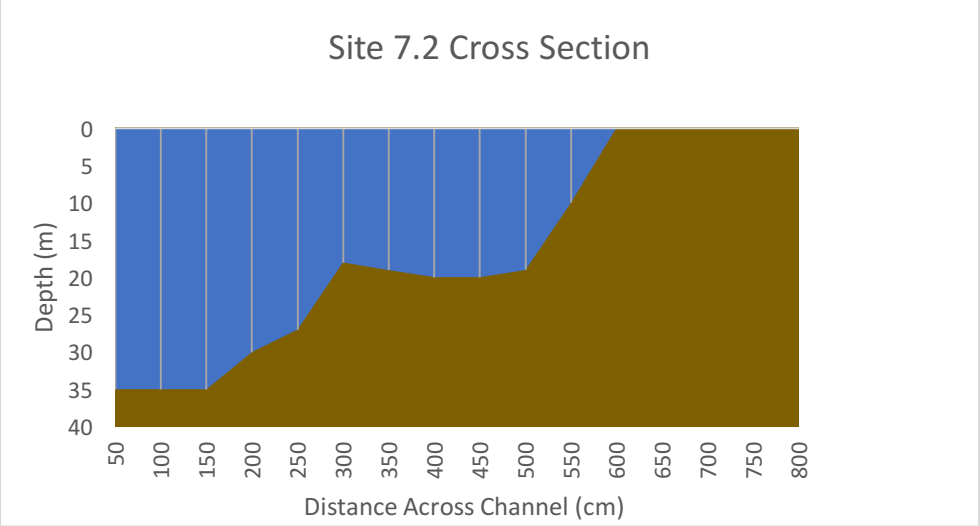


Figure 37 River cross section 7.2

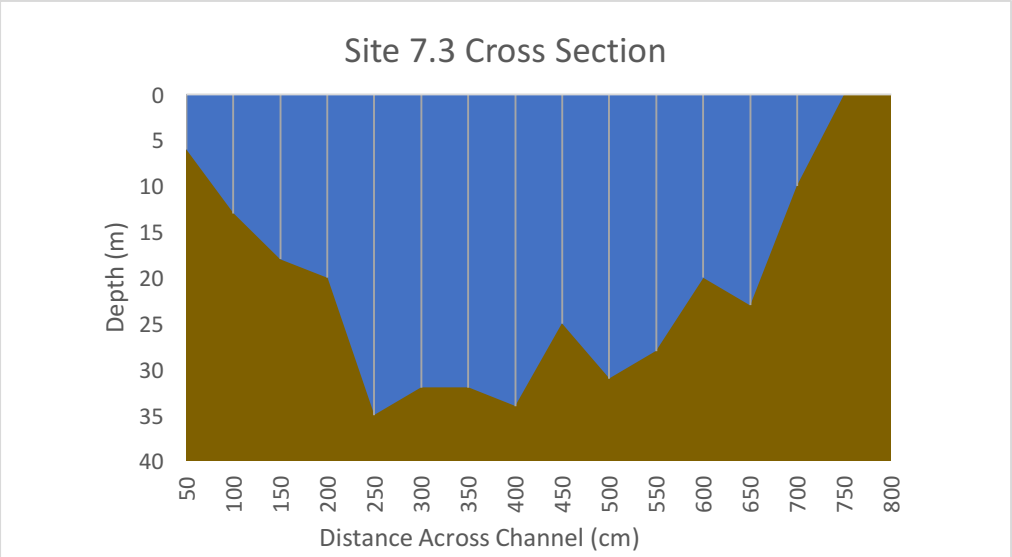


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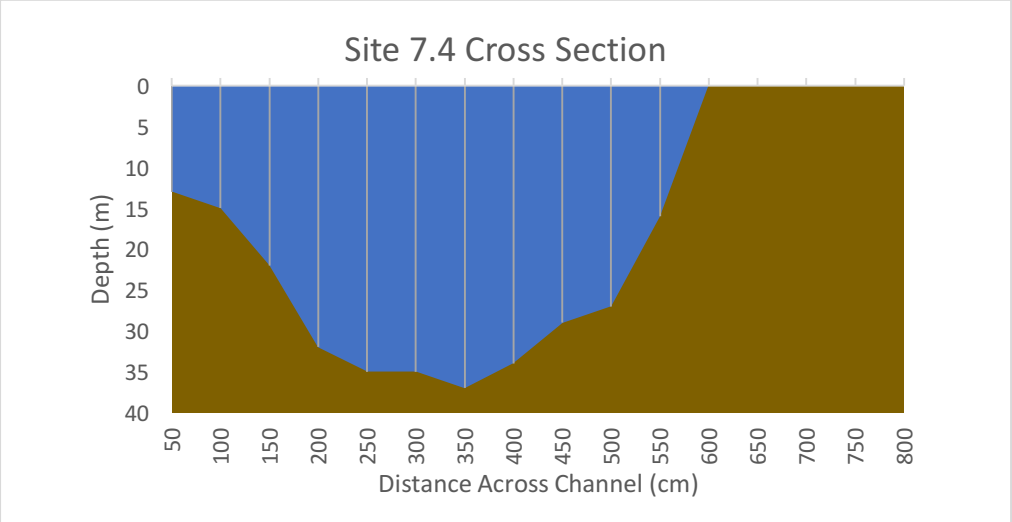


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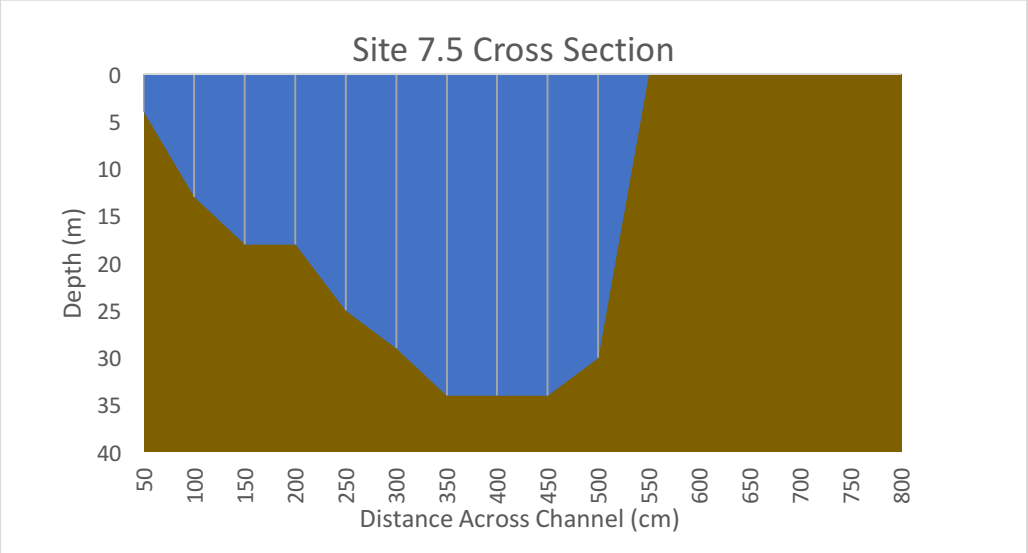


Figure 40 River cross section 7.5

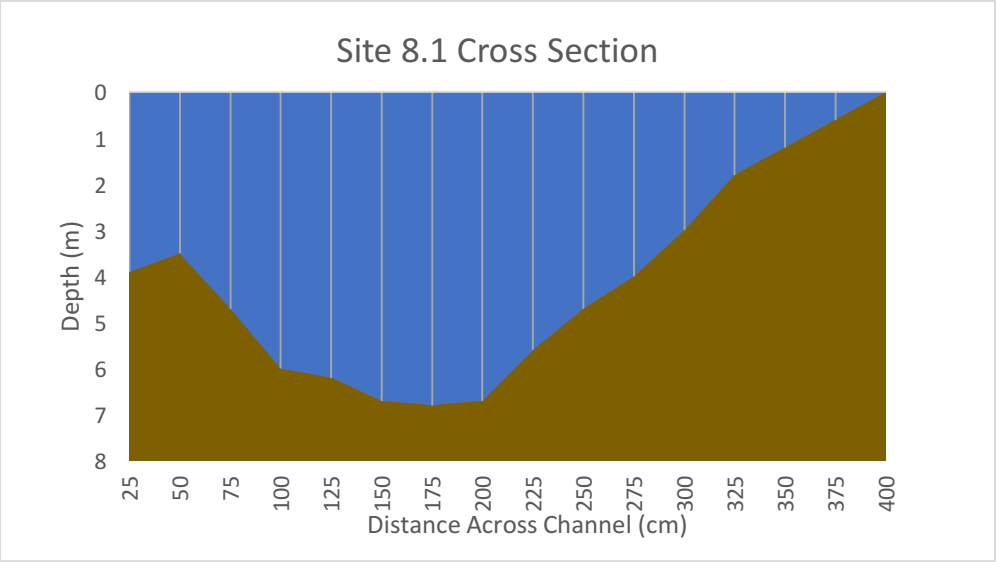


Figure 41 River cross section 8.1

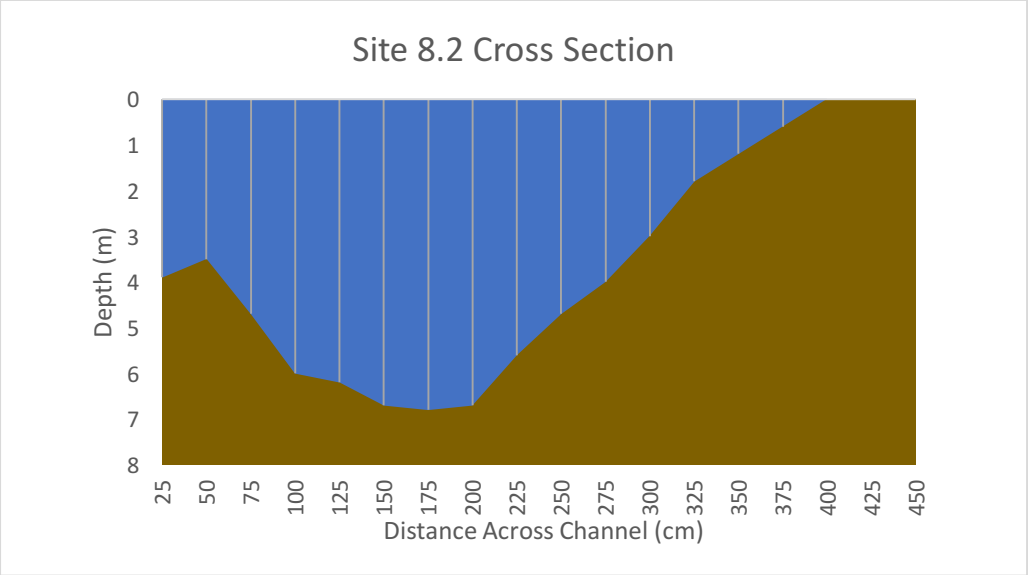


Figure 42 River cross section 8.2

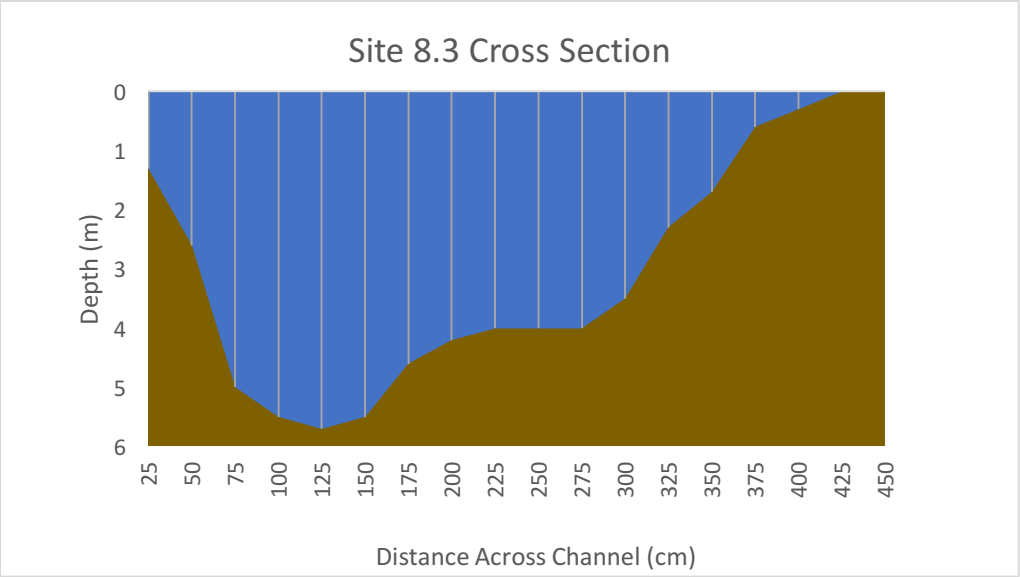


Figure 43 River cross section 8.3

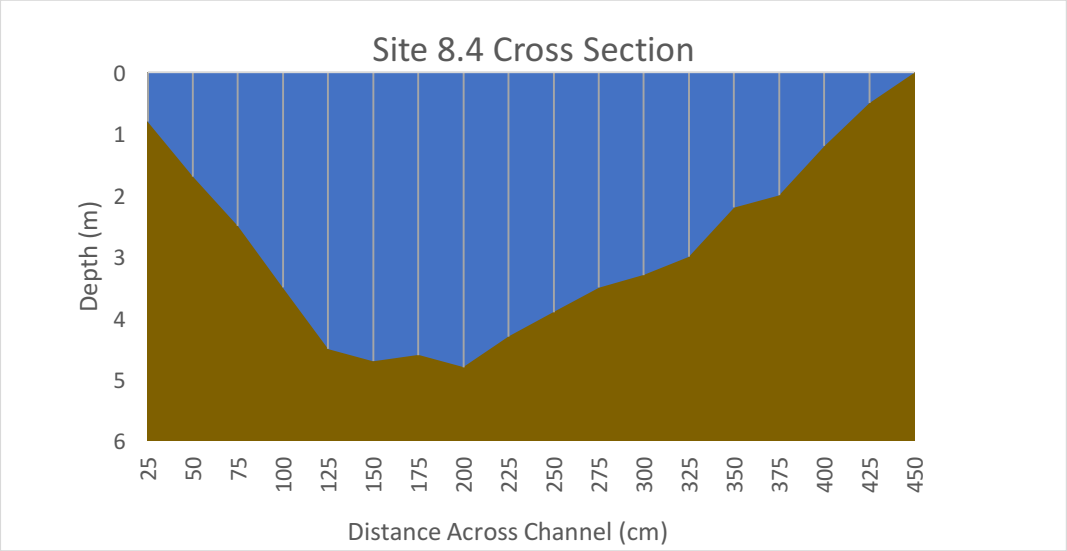


Figure 44 River cross section 8.4

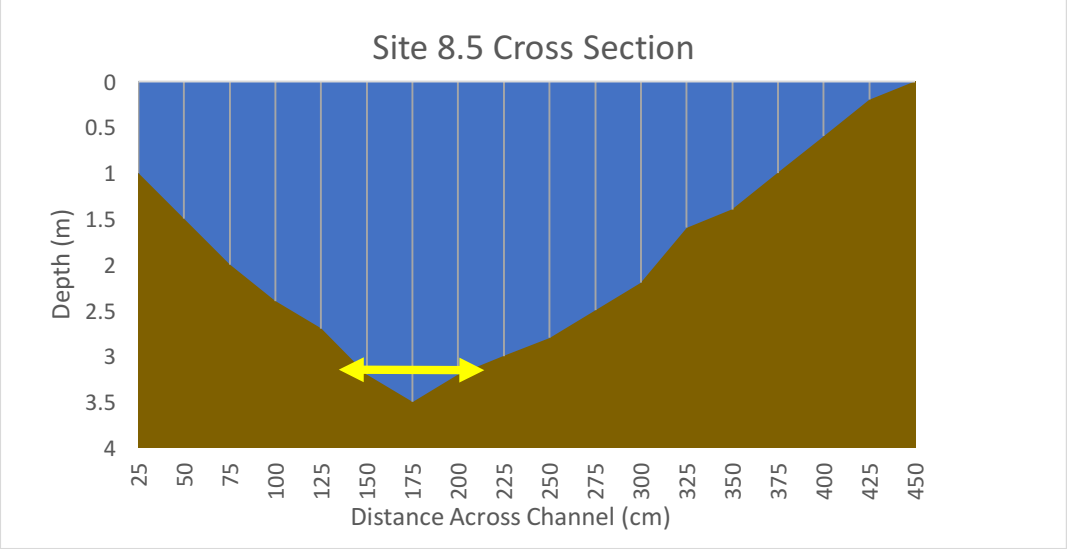


Figure 45 River cross section 8.5

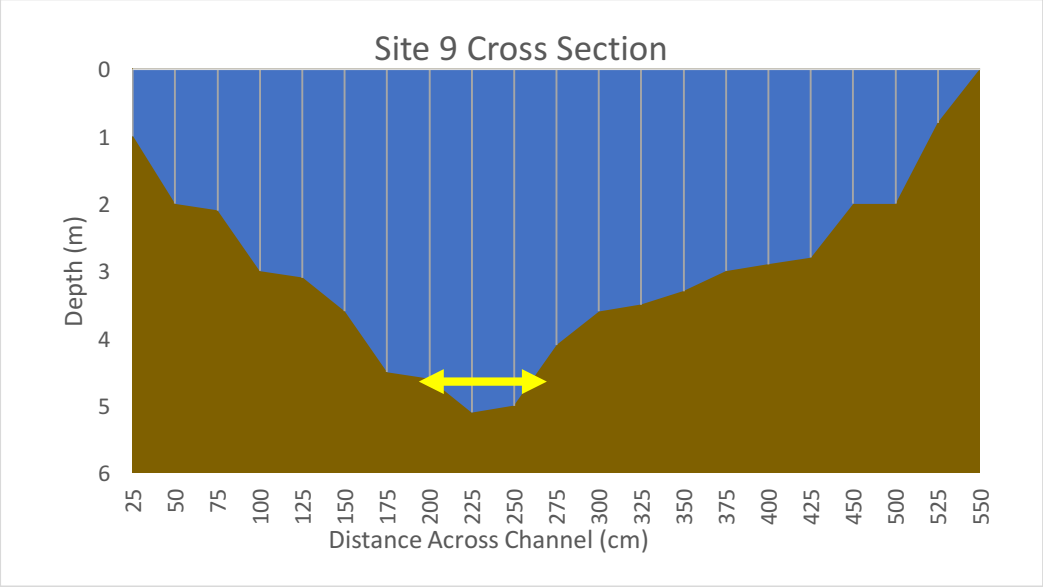


Figure 46 River cross section 9

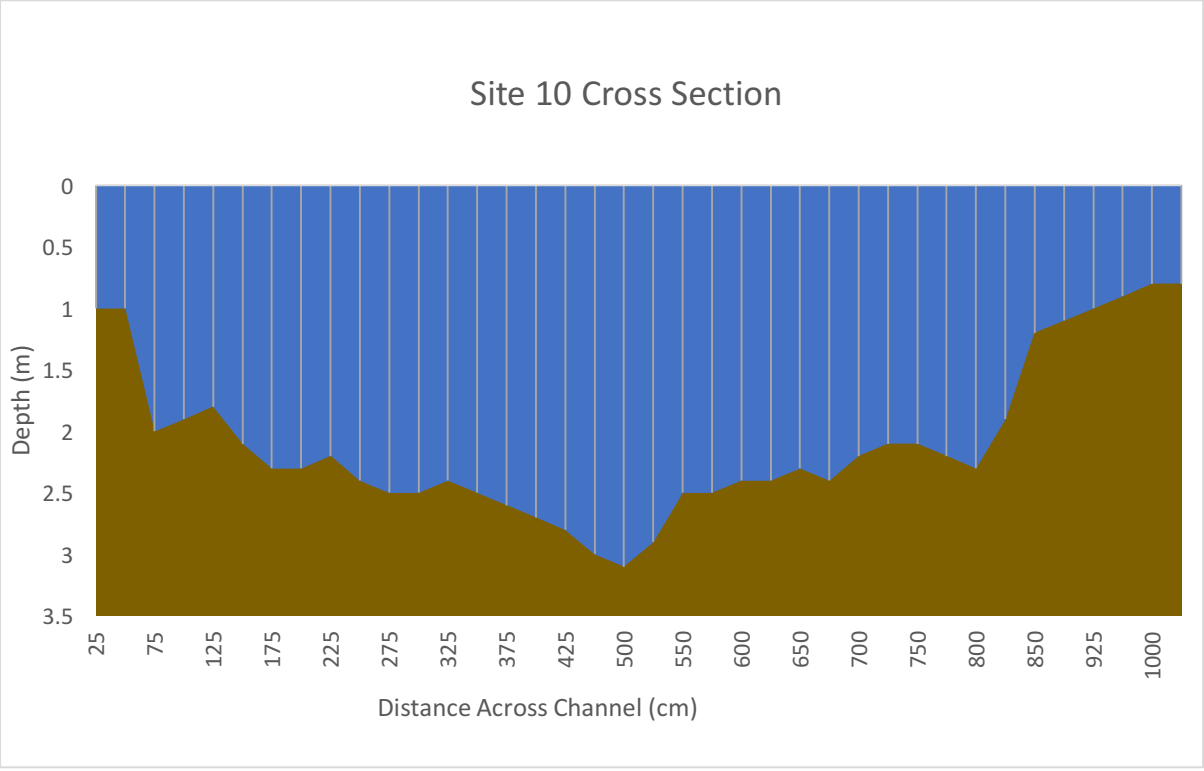


Figure 47 River cross section 10

Hypothesis 3 - The river velocity increases on the outside of a meander 5.3

No Meanders were studied during this Trip

Hypotheses 4 - The Highest Velocity is to be found in the centre of the river 5.4

There was insufficient equipment available to provide quantifiable data collection for the analysis of this hypothesis. However, from the one site that was measured, Site 7, it appears the rivers highest velocity is to be found in the centre with a surface flow of 1.16. This may also be observationally supported by regarding cross section figures; 2.4, 7.1, 7.2, 8.5 and 9 highlighted with yellow lines. At these points, the thalweg appears central with hydraulic action affecting the riverbeds shape, indicating at these points the highest velocity may be found in the centre of the river.

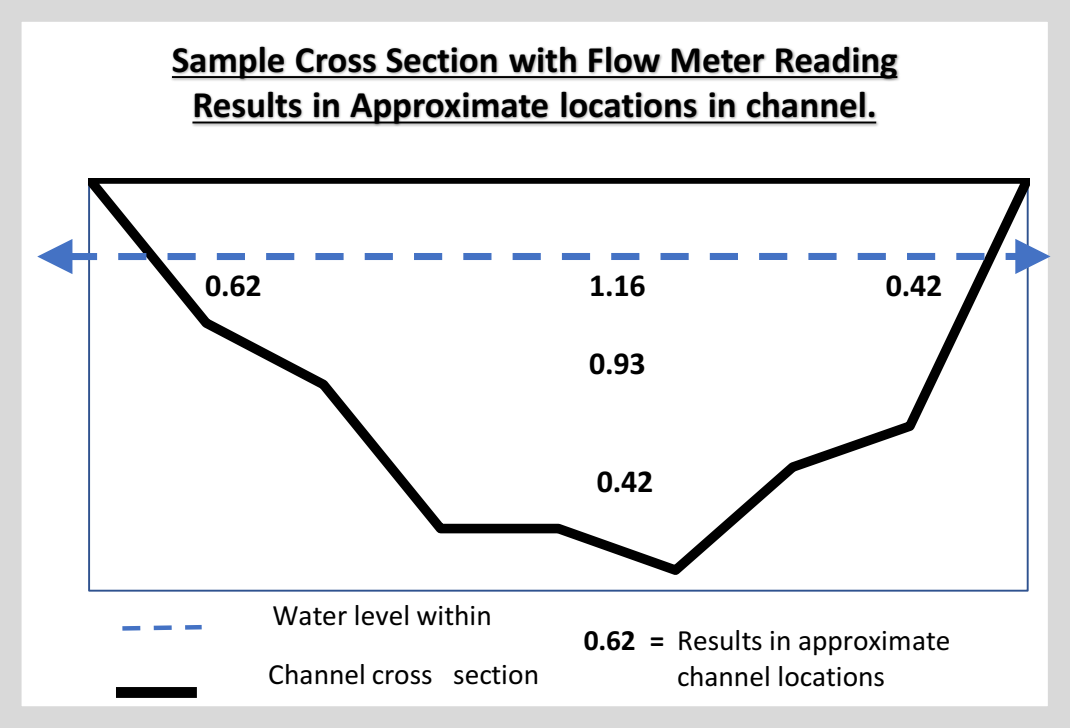


Figure 48 Diagram showing velocity meter results

Hypotheses 5 – The river velocity decreases downstream 5.5

From the data it appears, quite contrarily to our hypothesis, that site 10 had the highest average stream velocity of 1.31m/s in comparison with site 1 which had the lowest velocity at 0.31m/s. The sites seemingly follow a steady minor increase from source to mouth, with the exception of site 3, which with a depth of 54.1cm could be considered an outlier. The water in this area was somewhat stagnant, with a fallen tree, just upstream, interrupting the natural flow regime. The stream velocity of 0.39 m/s was only marginally more forceful than Site 1, which was marshland, with a highly vegetative riverbed and riparian zone affecting flow speed.

It would appear from the quantitative results, testing an opposing hypothesis, highlighted in fig 52, there is a positive linear relationship of r2 0.76 indicating the river velocity in fact increases downstream rather than decreases. SR statistical testing concluded a coefficient value of 0.98, almost a perfect correlation supporting the newly proposed hypothesis that in fact the river velocity increases downstream, as such, the original hypothesis was proven unsubstantiated.

In addition, through observational analysis it would appear the flow is helicoidal, a flow pattern typically observed in meandering rivers. The helicoidal motion aids hydraulic action on the outside of a meander and with a sweeping motion carries sediment towards the proceeding downstream inner curve . (Hickin, 2003). This process forms point bars which were evident at different points along the river course.



Figure 49 Photo showing turbulent helicoidal flow –note the meandering curve crossing the channel highlighted with red arrow. Photo credit- Natasha rose Dodds

Site Location	Distance (m)	Av. Time (secs)	Av. Surface Velocity (m/s)	Av. Stream Velocity (m/s)
Site 1	3	7.98	0.37593985	0.319548872
Site 2	10	9.94	1.006036217	0.855130785
Site 3	10	21.6	0.462962963	0.393518519
Site 4	5	5.3	0.943396226	0.801886792
Site 5	10	9.3	1.075268817	0.913978495
Site 6	10	9.84	1.016260163	0.863821138
Site 7	10	9.15	1.092896175	0.928961749
Site 8	10	8.14	1.228501229	1.044226044
Site 9	10	8.06	1.240694789	1.054590571
Site 10	10	6.48	1.543209877	1.311728395

Figure 50 Data box showing Velocity Results

Site	AV Stream Velocity (m/s)
1	0.32
2	0.85
3	0.39
4	0.8
5	0.91
6	0.86
7	0.93
8	1.04
9	1.05
10	1.31

Figure 51 Data box showing Average Velocity Results

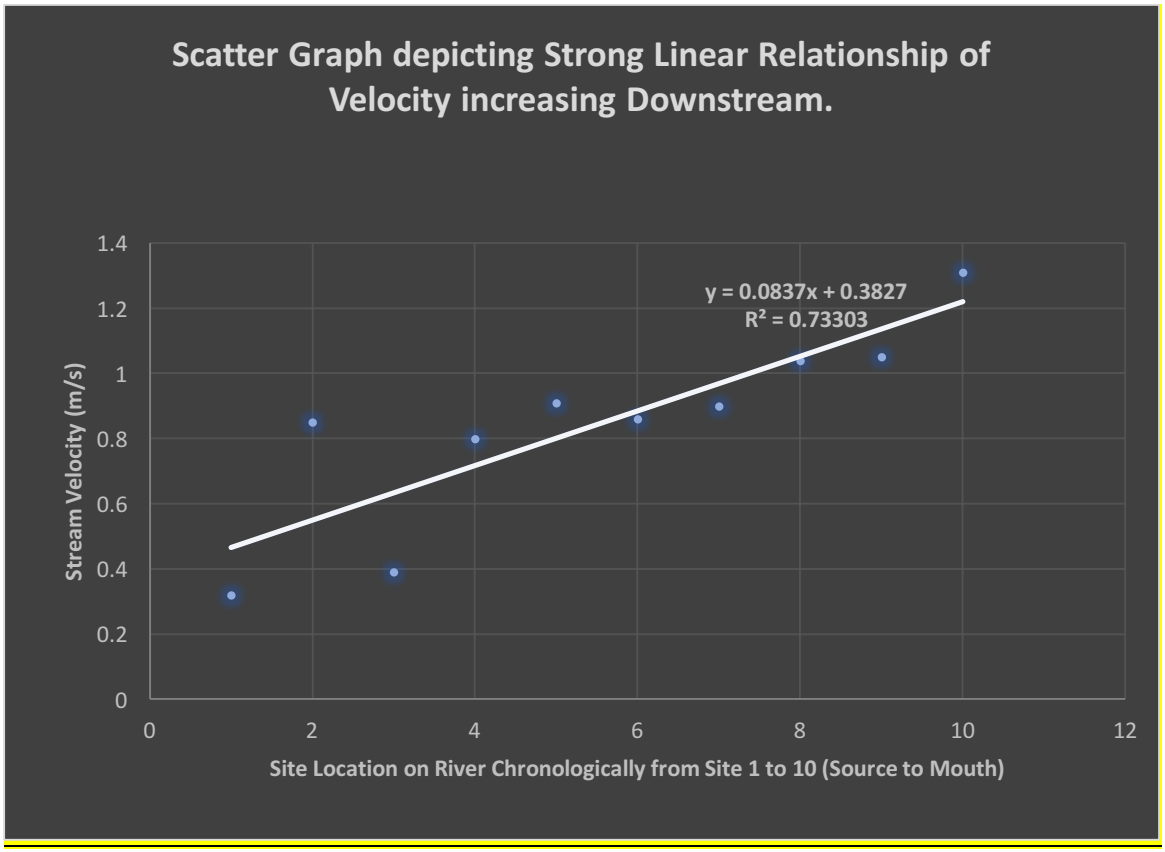


Figure 52 Scatter graph showing velocity relationship

Hypotheses 6 – The size of the bedload gets smaller downstream - 5.6

The bedload does appear to get moderately smaller downstream with sites 8, 9 and 10 showing a steady decrease in size. Site 10 had the smallest average axis of 1.8 and a range of 2, while Site 7 had the largest sample axis of 20.4 and a range of 15. When considering the quantitative results there appears to be little correlation to this hypothesis. The scatter is random and the non-linear relationship has an r2 value of 0.1. The coefficient value is -081, an almost perfect negative result.

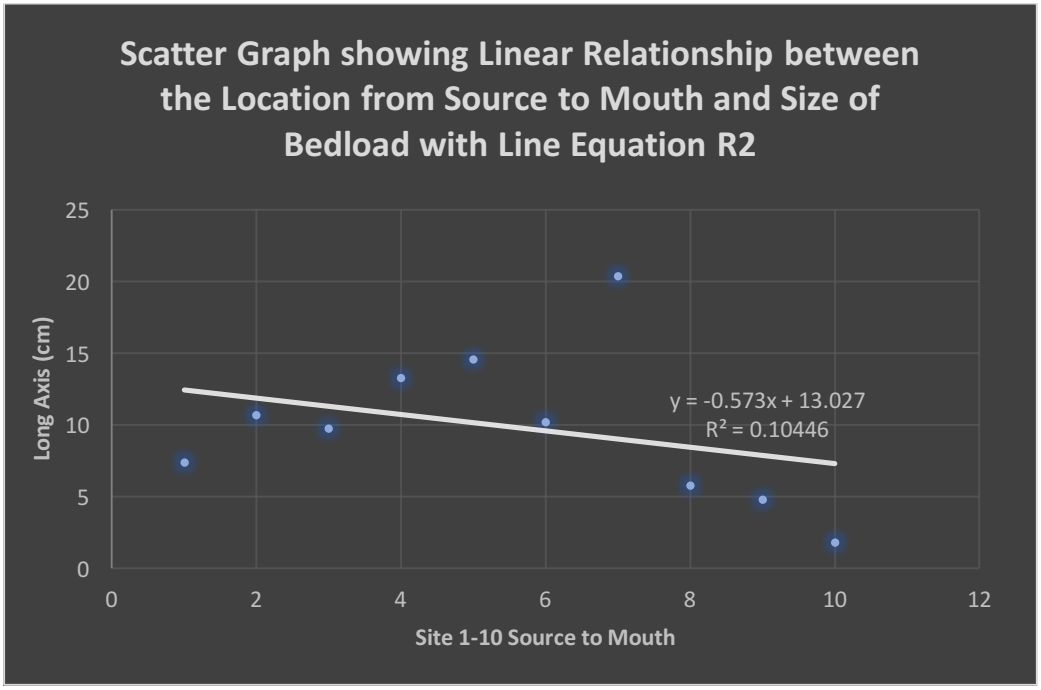


Figure 53 Scatter graph - Bedload

Site	Average Long Axis (cm)	Range Long Axis
1	7.4	4
2	10.7	6
3	9.75	7
4	13.3	7
5	14.6	10
6	10.2	7
7	20.4	15
8	5.8	4
9	4.8	4
10	1.8	2

Figure 54 Data box showing Average Long Axis

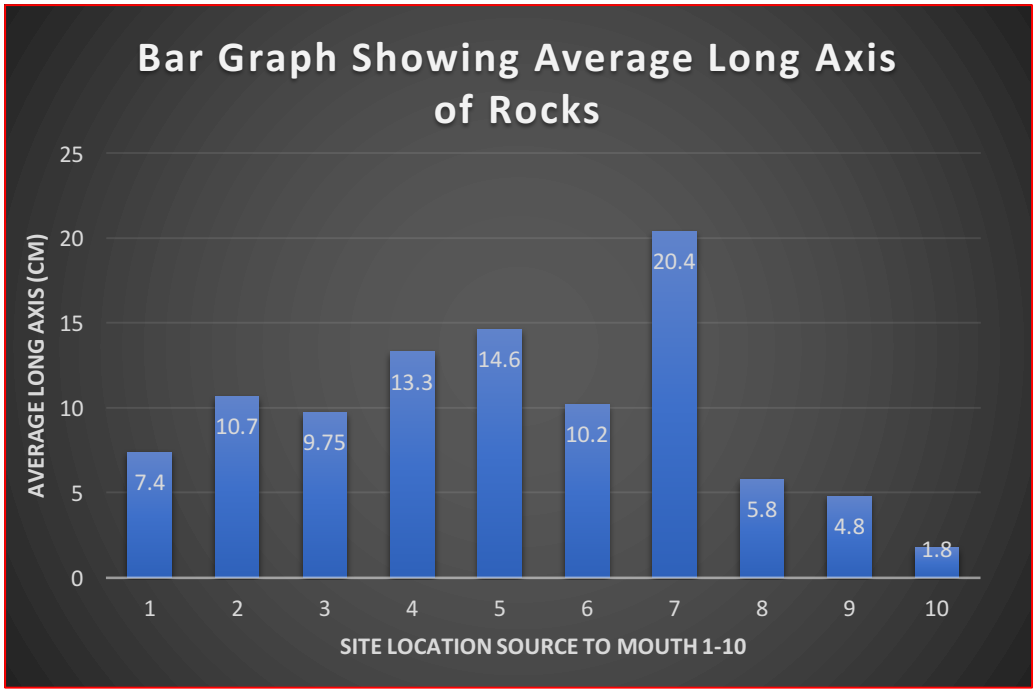


Figure 55 Bar Graph showing Average Long Axis

Site	Point	Long Axis (cm)	Roundness
	.		
1	1.1	9	angular
	1.2	8	sub.ang
	1.3	6	sub.ang
	1.4	5	sub.ang
	1.5	9	sub.ang
	Average	7.4	
2	1.1	9	Sub rounded
	1.2	9.5	Sub angular
	1.3	13	Very angular
	1.4	8	Angular
	1.5	14	Rounded
	Average	10.7	
3	3.1	13	Rounded
	3.2	12	Sub rounded
	3.3	6	Angular
	3.4	8	Sub rounded
	Average	9.75	
4	4.1	13	Rounded
	4.2	9	Sub rounded
	4.3	15	Sub angular
	4.4	13.5	Sub rounded
	4.5	16	Sub angular
	Average	13.3	
5	5.1	14	very.ang
	5.2	16	angular
	5.3	11	sub.ang
	5.4	21	sub.ang
	5.5	11	sub.ang
	Average	14.6	
6	6.1	6	sub.amg
	6.2	12	sub.ang
	6.3	11	sub.round
	6.4	13	sub.round
	6.5	9	round.
	Average	10.2	
7	7.1	21	Angular
	7.2	27	Sub angular
	7.3	23	Sub angular
	7.4	12	Sub angular
	7.5	19	Angular
	Average	20.4	
8	8.1	8	rounded
	8.2	6	rounded
	8.3	7	sub.round
	8.4	4	sub.round
	8.5	4	very.round
	Average	5.8	
9	9.1	6	sub.ang
	9.2	7	sub.round
	9.3	3	round
	9.4	4	v.round
	9.5	4	v.round
	Average	4.8	
10	10.1	2	sub.round
	10.2	3	round
	10.3	1	round
	10.4	1	v.round
	10.5	2	sub.round
	Average	1.8	

Figure 56 Results Table Substratum

Hypotheses 7: The shape of the bedload becomes more rounded downstream - 5.7

With regards to the shape of the bedload. The highest proportion of rounded and very rounded substratum, true to theory, was found furthest downstream from sites 8 -10, though angular or sub angular substratum was found at the majority of sites along the river, fig 57 depicts the angularity results. The greatest range of substratum was at site 2.

It would appear from the data that though the bedload does get more rounded downstream, it exhibits no obvious preferential sorting. With this in mind, the hypothesis remains somewhat inconclusive.

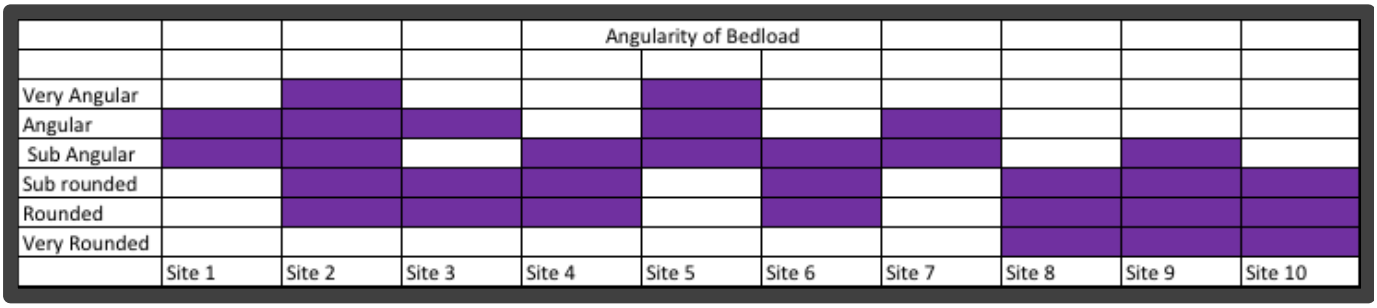


Figure 57 Data chart showing Angularity of Bedload

Hypotheses 8: The Discharge of the river increases downstream - 5.8

When considering the data regarding the discharge, Site 1 did have the lowest discharge of 1m/s3 but the highest volume was in the mid-course, site 5 at 16 m/s3. Sites 9 and 10 had relatively low discharge of 1.7 and 3.7m/s3. Fig 59, Shows random scatter indicating bare to no relationship and an r2 linear value of 0.0003. SR statistical tests found a coefficient value of 0.2 a weak correlation, but a correlation none the less. To further investigate this correlation, a broader range of data would be required, as well more robust statistical testing and the use of hydrographs.

Site Location	Average Cross Sectional Area (m2)	Average Stream Velocity (m/s)	Discharge (m/3s)
Site 1	3.14	0.32	1.0048
Site 2	3.07	0.85	2.6095
Site 3	22.5	0.39	8.775
Site 4	10.3	0.8	8.24
Site 5	17.9	0.91	16.289
Site 6	2.7	0.86	2.322
Site 7	15.2	0.93	14.136
Site 8	2.9	1.04	3.016
Site 9	1.7	1.05	1.785
Site 10	2.9	1.31	3.799

Figure 58 Data box showing Discharge results

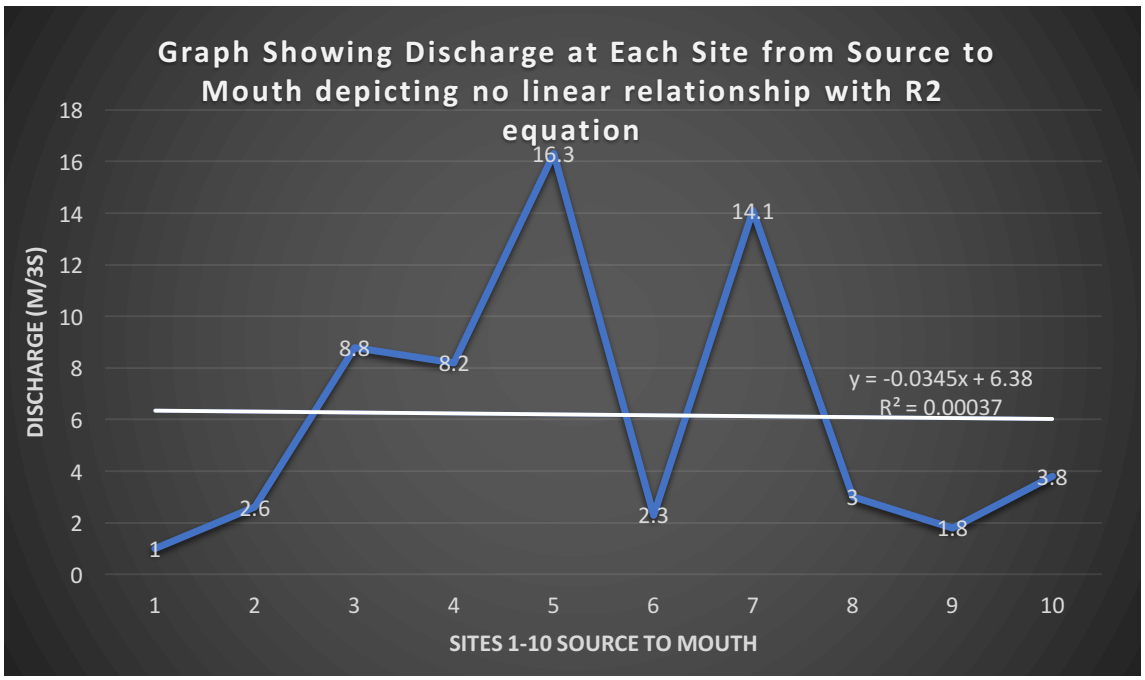


Figure 59 Scatter graph Discharge

Conclusions 6.0

In conclusion, it would appear that there are many processes contributing to the changing characteristics of the river and few of the conclusions were as expected.

A separate hypothesis was proposed upon reflection of the data regarding the velocity decreasing downstream and although the original hypothesis was disproven, a clearer understanding of the process was obtained.

There was a general trend towards negative correlations regarding the hypotheses in question, and as a whole, in order to accurately support or deny the proposed hypotheses, a further study into the drainage catchment, the use of hydrographs and a deeper understanding of the geological layout could prove beneficial. In addition, the use of erosion pins and clear consideration of anthropogenic effects present such as river channelling could provoke more definitive conclusions.

Furthermore, a more quantifiable degree of data collection, involving technologically advanced methods/equipment over a more ranging temporal and climatic span, with the engagement of more robust statistical tests, such as running a multiple linear regression algorithm, could also aid in clarifying the extent of correlation present and provide deeper insight into the processes at work and their effects in relation to one another, thus enabling a further understanding of the changing characteristics to aid future management

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Appendices 8.0

Spearman's Rank

Does the width increase downstream?

		Ilston River Spearmans Rank			
Distance	Rank	Width (cm)	Rank	d	d2
1.1	33	2	32.5	0.5	0.25
1.2	32	2	32.5	-0.5	0.25
1.3	31	2.4	31	0	0
1.4	30	2.7	29.5	0.5	0.25
1.5	29	2.7	29.5	-0.5	0.25
2.1	28	3.6	26	2	4
2.2	27	4.5	20	7	49
2.3	26	3.8	24.5	1.5	2.25
2.4	25	5.9	11	14	196
2.5	24	3.4	27	-3	9
3.1	23	5.2	18	5	25
3.2	22	4.8	19	3	9
3.3	21	5.5	15	6	36
3.4	20	6.2	7	13	169
4.1	19	6	10	9	81
5.1	18	6.1	8.5	9.5	90.25
6.1	17	3.15	28	-11	121
6.2	16	4.2	21	-5	25
6.3	15	4	22.5	-7.5	56.25
6.4	14	4	22.5	-8.5	72.25
6.5	13	3.8	24.5	-11.5	132.25
7.1	12	7.6	4	8	64
7.2	11	5.5	15	-4	16
7.3	10	7.3	5	5	25
7.4	9	5.5	15	-6	36
7.5	8	5.4	17	-9	81
8.1	7	5.6	12.5	-5.5	30.25
8.2	6	6.4	6	0	0
8.3	5	5.6	12.5	-7.5	56.25
8.4	4	8.2	3	1	1
8.5	3	8.4	2	1	1
9.1	2	6.1	8.5	-6.5	42.25
10.1	1	14.2	1	0	0
				Sum of	1431
				N	33
				n3	35937
				n3-n	35904
				r/s	0.76086

Spearman's Rank

Does the depth increase downstream?

Distance	Rank	Av Depth cm	Rank	d	d2
1.1	33	13.7	13	20	400
1.2	32	14	11.5	20.5	420.25
1.3	31	11.3	15.5	15.5	240.25
1.4	30	13.4	14	16	256
1.5	29	14	11.5	17.5	306.25
2.1	28	7.8	21	7	49
2.2	27	9.7	17	10	100
2.3	26	9.6	18	8	64
2.4	25	7.9	20	5	25
2.5	24	9.1	19	5	25
3.1	23	40.4	4	19	361
3.2	22	64.4	1	21	441
3.3	21	50.8	2	19	361
3.4	20	50.1	3	17	289
4.1	19	17.3	10	9	81
5.1	18	29.4	5	13	169
6.1	17	2.7	27.5	-10.5	110.25
6.2	16	11.3	15.5	0.5	0.25
6.3	15	2.7	27.5	-12.5	156.25
6.4	14	2.3	30.5	-16.5	272.25
6.5	13	2.6	29	-16	256
7.1	12	2.3	30.5	-18.5	342.25
7.2	11	24.4	7	4	16
7.3	10	23.8	9	1	1
7.4	9	27	6	3	9
7.5	8	23.9	8	0	0
8.1	7	3.9	22	-15	225
8.2	6	3.4	23	-17	289
8.3	5	3.3	24	-19	361
8.4	4	2.8	26	-22	484
8.5	3	1.9	33	-30	900
9.1	2	2.9	25	-23	529
10.1	1	2.1	32	-31	961
				SUM	8500
				n	33
				n3	35937
				n3-n	35904
				r/s	-0.4205

Spearman's Rank

Does the Cross-sectional area increase?

Distance	Rank	Cross Sec are	Rank	Distance	d2	d2
1.1	33	32.568	20	13	169	2197
1.2	32	33.04	18.5	13.5	182.25	2460.4
1.3	31	26.668	24	7	49	343
1.4	30	31.624	21	9	81	729
1.5	29	33.04	18.5	10.5	110.25	1157.6
2.1	28	33.93	16	12	144	1728
2.2	27	41.225	13	14	196	2744
2.3	26	40.8	14	12	144	1728
2.4	25	33.575	17	8	64	512
2.5	24	38.675	15	9	81	729
3.1	23	218.968	4	19	361	6859
3.2	22	349.048	1	21	441	9261
3.3	21	275.336	2	19	361	6859
3.4	20	271.542	3	17	289	4913
4.1	19	103.8	11	8	64	512
5.1	18	179.34	5	13	169	2197
6.1	17	9.958	31	-14	196	2744
6.2	16	43.279	12	4	16	64
6.3	15	10.341	30	-15	225	3375
6.4	14	8.809	33	-19	361	6859
6.5	13	9.575	32	-19	361	6859
7.1	12	143.98	10	2	4	8
7.2	11	152.744	7	4	16	64
7.3	10	148.988	9	1	1	1
7.4	9	169.02	6	3	9	27
7.5	8	149.614	8	0	0	0
8.1	7	26.676	23	-16	256	4096
8.2	6	23.256	25	-19	361	6859
8.3	5	22.572	26	-21	441	9261
8.4	4	19.152	27	-23	529	121576
8.5	3	12.996	29	-26	676	17575
9.1	2	17.69	28	-26	676	17576
10.1	1	29.82	22	-21	441	9621
					sum	7474.5
					n	33
					n3	35937
					n3-n	35904
					r/s	-0.2491

Spearman's Rank

Does the velocity increase downstream (opposing theory proposed)?

Distance	Rank	Velocity M/s	Rank	Distance	d2
1.1	44	0.26	44	0	0
1.2	43	0.6	36	7	49
1.3	42	0.48	38	4	16
1.4	41	0.28	43	2	4
1.5	40	0.29	42	2	4
2.1	39	0.98	32	7	49
2.2	38	1.08	25	13	169
2.3	37	0.96	33	5	25
3.1	36	0.43	40.5	4.5	20.25
3.2	35	0.51	37	2	4
3.3	34	0.45	39	5	25
4.1	33	1.95	1	32	1024
4.2	32	0.99	31	1	1
4.3	31	1.76	3	28	784
4.4	30	1.92	2	28	784
4.5	29	0.43	40.5	11.5	132.25
5.1	28	1.09	21	7	49
5.2	27	1.05	28.5	1.5	2.25
5.3	26	1.08	25	1	1
5.4	25	1.26	12.5	12.5	156.25
5.5	24	0.92	34	10	100
6.1	23	1	30	7	49
6.2	22	1.08	25	3	9
6.3	21	0.87	35	14	196
6.4	20	1.2	16.5	3.5	12.25
6.5	19	1.14	18.5	0.5	0.25
7.1	18	1.05	28.5	10.5	110.25
7.2	17	1.14	18.5	1.5	2.25
7.3	16	1.08	25	9	81
8.1	15	1.12	20	5	25
8.2	14	1.08	25	6	36
8.3	13	1.31	11	2	4
8.4	12	1.23	14	2	4
8.5	11	1.44	9	2	4
9.1	10	1.45	8	2	4
9.2	9	1.22	15	6	36
9.3	8	1.26	12.5	4.5	20.25
9.4	7	1.2	16.5	9.5	90.25
9.5	6	1.11	21	15	225
10.1	5	1.47	7	2	4
10.2	4	1.69	4	0	0
10.3	3	1.61	5	2	4
10.4	2	1.53	6	4	16
10.5	1	1.42	10	9	81
				sum	4412.5
				n	44
				n3	85184
				n3-n	85140
				r/s	5.73
					0.94817

Spearman's Rank

Does the Discharge increase downstream?

Distance	Rank	Discharge	Rank	Distance	d2	d2
1.1	33	10.42176	29	4	4	16
1.2	32	10.5728	27.5	4.5	4.5	20.25
1.3	31	8.53376	32	-1	1	1
1.4	30	10.11968	30	0	0	0
1.5	29	10.5728	27.5	1.5	1.5	2.25
2.1	28	39.9176471	15	13	13	169
2.2	27	48.5	12	15	15	225
2.3	26	48	13	13	13	169
2.4	25	2.18685121	33	-8	8	64
2.5	24	45.5	14	10	10	100
3.1	23	19.1124988	20	3	3	9
3.2	22	894.994872	1	21	21	441
3.3	21	705.989744	2	19	19	361
3.4	20	696.261539	3	17	17	289
4.1	19	129.75	10	9	9	81
5.1	18	197.076923	4	14	14	196
6.1	17	18.4418605	21	-4	4	16
6.2	16	50.3244186	11	5	5	25
6.3	15	12.0244186	25	-10	10	100
6.4	14	10.2430233	30	-16	16	256
6.5	13	11.1337209	26	-13	13	169
7.1	12	154.817204	9	3	3	9
7.2	11	164.24086	6	5	5	25
7.3	10	160.202151	8	2	2	4
7.4	9	181.741936	5	4	4	16
7.5	8	160.875269	7	1	1	1
8.1	7	25.65	16	-9	9	81
8.2	6	22.3615385	18	-12	12	144
8.3	5	21.7038462	19	-14	14	196
8.4	4	18.4153846	22	-18	18	324
8.5	3	12.5326923	24	-21	21	441
9.1	2	16.8476191	23	-21	21	441
10.1	1	22.7633588	17	-16	16	256
					sum	4647.5
					n	33
					n3	35937
					n3-n	35904
						0.2233

Spearman's Rank

Does the Bedload get smaller downstream?

dist	rank	long axis	Rank	d	d2
1.1	49	9	25	24	576
1.2	48	8	29.5	18.5	342.25
1.3	47	6	36	11	121
1.4	46	5	39	7	49
1.5	45	9	25	20	400
1.1	44	9	25	19	361
1.2	43	9.5	22	21	441
1.3	42	13	13.5	28.5	812.25
1.4	41	8	29.5	11.5	132.25
1.5	40	14	9.5	30.5	930.25
3.1	39	13	13.5	25.5	650.25
3.2	38	12	17	21	441
3.3	37	6	36	1	1
3.4	36	8	29.5	6.5	42.25
4.1	35	13	13.5	21.5	462.25
4.2	34	9	25	9	81
4.3	33	15	8	25	625
4.4	32	13.5	11	21	441
4.5	31	16	6.5	24.5	600.25
5.1	30	14	10	20	400
5.2	29	16	6.5	22.5	506.25
5.3	28	11	20	8	64
5.4	27	21	3.5	23.5	552.25
5.5	26	11	20	6	36
6.1	25	6	36	-11	121
6.2	24	12	17	7	49
6.3	23	11	20	3	9
6.4	22	13	13.5	8.5	72.25
6.5	21	9	25	-4	16
7.1	20	21	3.5	16.5	272.25
7.2	19	27	1	18	324
7.3	18	23	2	16	256
7.4	17	12	17	0	0
7.5	16	19	5	11	121
8.1	15	8	29.5	-14.5	210.25
8.2	14	6	36	-22	484
8.3	13	7	32.5	-19.5	380.25
8.4	12	4	41.5	-29.5	870.25
8.5	11	4	41.5	-30.5	930.25
9.1	10	6	36	-26	676
9.2	9	7	32.5	-23.5	552.25
9.3	8	3	44.5	-36.5	1332.25
9.4	7	4	41.5	-34.5	1190.25
9.5	6	4	41.5	-35.5	1260.25
10.1	5	2	46.5	-41.5	1722.25
10.2	4	3	44.5	-40.5	1640.25
10.3	3	1	5	-2	4
10.4	2	1	48.5	-46.5	2162.25
10.5	1	2	46.5	-45.5	2070.25
				sum	25793
				n	44
				n3	85184
				n3-n	85140
				r/s	-0.8177