# A Geographical Study of the Glade and Carmichael Burn

Word Count: 3061

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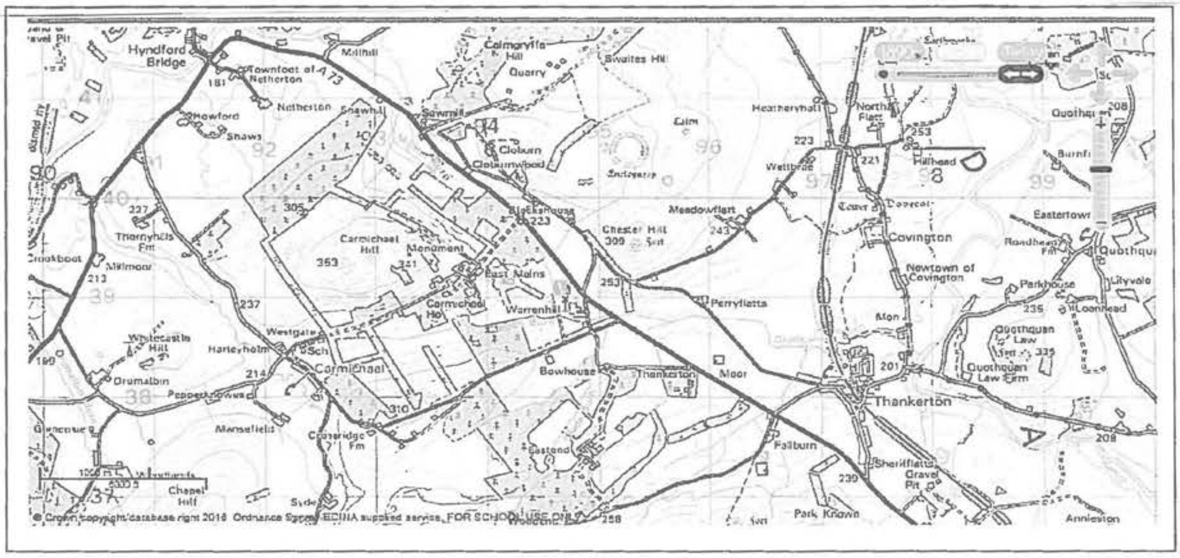
## Contents Page

## Introduction

The two burns being studied, the Carmichael and Glade Burn, are both tributary streams of the River Clyde and are situated near Lanark, South Lanarkshire. Land surrounding the rivers is predominantly used for farming. Figure 1 below identifies both rivers.

Figure 1: Location of Study




The area under investigation on the Carmichael Burn was between site 1 and site 8 as seen in Figure 3 below. Sites investigated on Glade Burn are located between site 1 and site 8 as seen in Figure 2 below.

Figure 2 Glade Burn

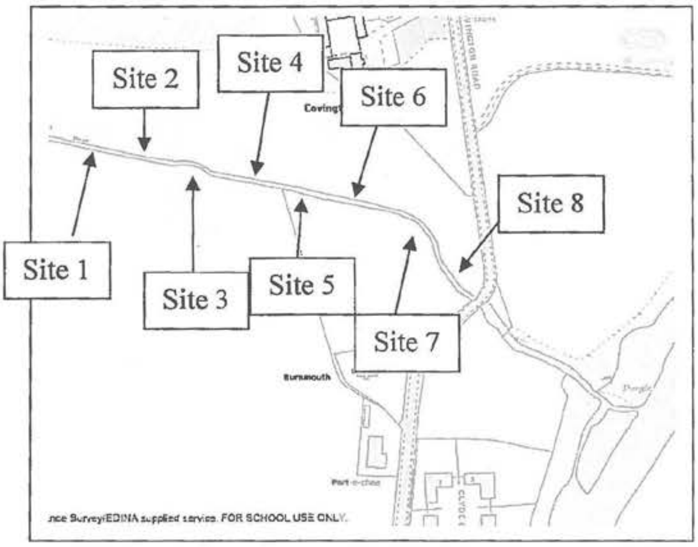



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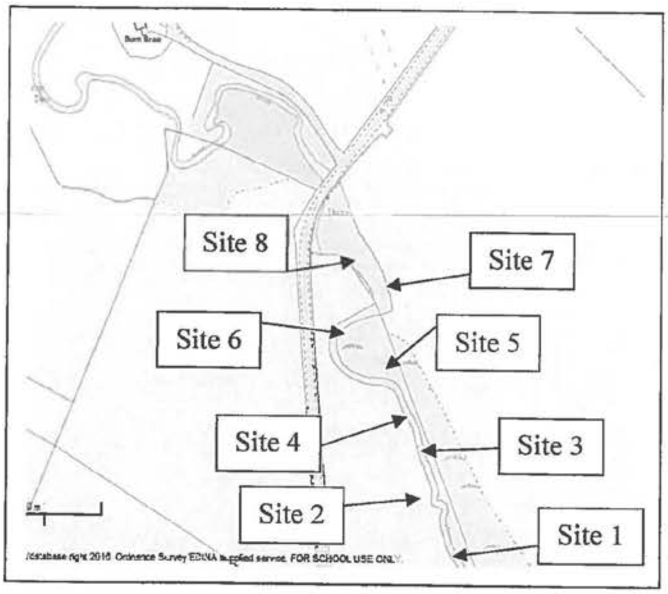
Figure 3: Carmichael Burn




In my study I am going to be comparing the drainage basin of both of rivers. For both I collected the same data so I could compare my result and investigate similarities and differences. Throughout this investigation, I plan to compare data collected across both rivers with the standard textbook model river.

I will process results using multiple statistical analyses techniques such as spearman's rank and Pearsons product. Additionally, in order to process the data collected, scatter graphs will be used to demonstrate correlations between various factors.

My aims are:

- To find out if there are differences in the drainage basins of both the Glade Burn and Carmichael Burn
- To determine if there is a relationship between depth and speed, and to relate findings to the 'model' river
- To determine if there is a relationship between width, speed and distance downstream
- To determine if water clarity is related to surrounding land use

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## Methodology

### Primary Sources

At each river I carried out my research at 8 different sites. Each of my sites was 100 metres apart so that my findings were more accurate and varied. At each individual site I measured the width of the river, and the depth at 0.5m intervals. To measure the width of the river I had a measuring tape and measured the area between one river bank and the other and recorded my results.

To measure the depth I used a meter stick and at every 0.5m intervals on the measuring tape I placed my meter stick into the river and lowered it until it hit the river bed and recorded the depth. Results may have been less reliable in areas that were deeper, or with rocks reducing accuracy of the readings. Re-taking the measurements, or moving along in some areas would ensure results were true of the site being measured.

I also measured the speed of the river on the inner, middle and outer bend. To do this I used a float-able item such as an orange and measured 10 metres from one area in the river. I then let the float go and using a stop watch recorded how long it took for the float to travel the set distance. I then divided the selected distance by the time recorded on the stopwatch to calculate the average speed. This can be less reliable in areas with differing depths or obstacles which would stop the float or slow it down, meaning results would be less accurate.

I assessed the clarity of the water by making observations. To do this I created a scale from 1-10, 1 being the worst and 10 being the best and scored the clarity of the water using this. If the river was at all discoloured I explained the reasons for this through what the land is used for in the surround-ing area. This is a subjective scale, so results would differ between people.

When I went to collect my data at my second river, the Carmichael Burn, during the days prior to my visit there was some snowfall which then melted and ran into the river. This therefore may have affected my results which I collected, especially my measurements for the depth of the river. This is because the excess water will have possibly increased the level of water in the river compared to normal meaning the river level will have not been at its usual level.

### Secondary Sources

I got information about rivers and their drainage basins from a variety of textbooks in class. This was very useful because it told me theories in which I could compare my results to determine whether or not my results were comparable to the normal model of a river.

I also used several different websites I found out on the internet to help support my analysis. Inter-net research can provide a great variety of resources, however, it can be a time consuming process. Many journals and reports were old, and therefore it was difficult finding up to date comparisons.

## Research Questions

The following research questions will be investigated, and within each one I will test a variety of hypothesis.

1. Does river speed vary with distance downstream across both rivers?
    - Hypothesis 1- There is a relationship between depth and distance
    - Hypothesis 2- Speed is affected by land use around the river
    - Hypothesis 3- Speed is affected by variations in the river.
2. Does river width vary with distance and speed
    - Hypothesis 4- river width will vary with increasing distance downstream
    - Hypothesis 5- river width will vary with increasing speed
3. Does river turbidity rely on surrounding land use?
    - Hypothesis 6- there is a relationship between land use and turbidity
    - Hypothesis 7- river depth will affect turbidity
4. Does river depth vary across both streams with increasing distance downstream?
    - Hypothesis 8- river depth will increase downstream
    - Hypothesis 9- river depth is related to width and speed

## 1. Does river speed change downstream?

David Waugh states that 'the velocity increases as the depth, width and discharge of a river increase.' [1]

According to class textbooks, as the distance downstream of a river increases so should its velocity, therefore a relationship should clearly be seen in both rivers. To process my data, Pearson's Product was chosen as it is widely used and it can show a powerful correlation between results.

Figure 4: Carmichael Burn

| Distance (m) (x) | Speed (m/s) (y) | (x- x̄) | (y- ȳ) | (x- x̄)² | (y- ȳ)² | (x- x̄)(y- ȳ) |
|---|---|---|---|---|---|---|
| 100 | 29.43 | -350 | -5.96 | 122,500 | 35.5216 | 2086 |
| 200 | 33.86 | -250 | -1.53 | 62500 | 2.3409 | 382.5 |
| 300 | 34 | -150 | -1.39 | 22500 | 1.9321 | 208.5 |
| 400 | 34.56 | -50 | -0.83 | 2500 | 0.6889 | 41.5 |
| 500 | 36.78 | 50 | 1.39 | 2500 | 1.9321 | 69.5 |
| 600 | 36.94 | 150 | 1.55 | 22500 | 2.4025 | 232.5 |
| 700 | 38 | 250 | 2.61 | 62500 | 6.8121 | 652.5 |
| 800 | 39.56 | 350 | 4.17 | 122500 | 17.3889 | 1459.5 |
| Σx=3600<br>x̄=450 | Σy=283.13<br>ȳ=35.39 | | | Σ=420000 | Σ=68.7135 | Σ=5132.5 |

R= $\frac{\Sigma(x-\bar{x})(y-\bar{y})}{\sqrt{\Sigma(x-\bar{x})^2(y-\bar{y})^2}}$ R= $\frac{5132.5}{\sqrt{28859670}}$ R= $\frac{5132.5}{5372.12}$ R= 0.95

Figure 5: Glade Burn

| Distance (m) (x) | Speed (m/s) (y) | (x- x̄) | (y- ȳ) | (x- x̄)² | (y- ȳ)² | (x- x̄)(y- ȳ) |
|---|---|---|---|---|---|---|
| 100 | 13.43 | -350 | -5.003 | 122,500 | 25.03 | 1751.05 |
| 200 | 15.375 | -250 | -3.058 | 62500 | 9.35 | 764.5 |
| 300 | 17.59 | -150 | -0.843 | 22500 | 0.71 | 126.45 |
| 400 | 17.95 | -50 | -0.483 | 2500 | 0.23 | 24.15 |
| 500 | 19.29 | 50 | 0.857 | 2500 | 0.73 | 42.85 |
| 600 | 20 | 150 | 1.567 | 22500 | 2.45 | 235.05 |
| 700 | 20.5 | 250 | 2.067 | 62500 | 4.27 | 516.75 |
| 800 | 23.33 | 350 | 4.897 | 122500 | 23.98 | 1713.95 |
| Σx=3600<br>x̄=450 | Σy= 147.465<br>ȳ= 18.433 | | | Σ=420000 | Σ=66.75 | Σ= 5174.75 |

R= $\frac{\Sigma(x-\bar{x})(y-\bar{y})}{\sqrt{\Sigma(x-\bar{x})^2(y-\bar{y})^2}}$ R= $\frac{5174.75}{\sqrt{28035000}}$ R= $\frac{5174.75}{5294.81}$ R= 0.98

The degrees of freedom (8-2=6) and at significance level 0.05, r must exceed 0.886. Our value of 0.95 for Carmichael Burn, and 0.98 for Glade Burn, shown in the table and equation above does

[1] Geography; An Integrated Approach, David Waugh, pg 62

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exceed the significance level for 6 degrees of freedom at 0.05. There is strong statistical evidence that there is a link between speed and depth on both streams. Based on this result, the null hypothesis can be rejected and the alternative hypothesis can be accepted that there is a relationship between speed and distance downstream.

Having already demonstrated the strength of the relationship between speed and distance on the Carmichael Burn and the Glade Burn using the Pearson's Product Moment correlation coefficient, the form of the relationship also needs to be displayed as shown by the scatter points on the graph below and on the following page. Using the results above a line of best fit using the linear regression analysis was undertaken.

Figure 6: Linear regression- Carmichael Burn

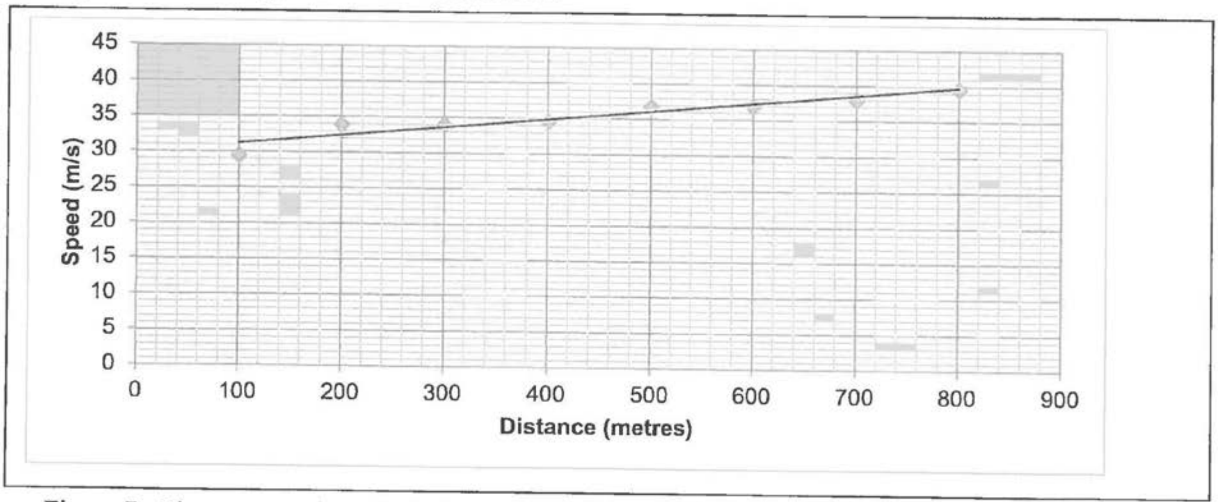
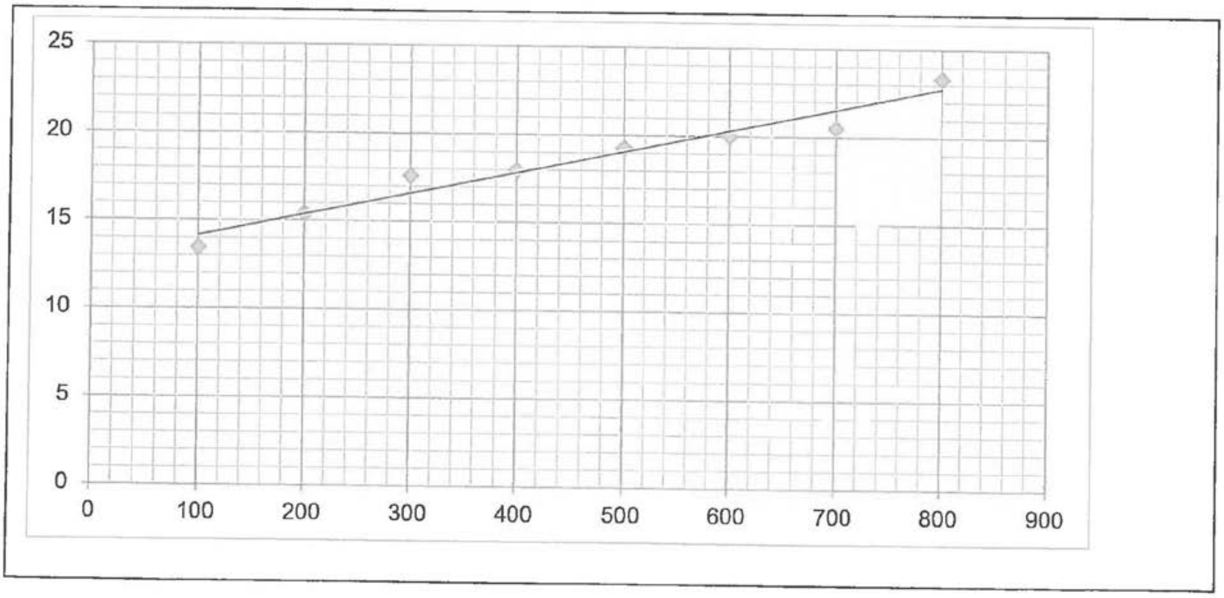



Figure 7: Linear regression- Glade Burn

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As a river progresses through its lower course the velocity increases as the river becomes more efficient.[2] This has been demonstrated through my findings and my results show that there is a relationship between speed and distance downstream. In both rivers as my points get further away from the source the width of the river increases. This is due to the fact that the river is deeper in the lower course of the river and is wider. The friction from the banks and the river bed is reduced because less water is in contact with the wetted perimeter.

Speed is not affected by land use around the river. Around both rivers there are fields which are used for agriculture reasons. There is no impermeable rock surrounding the river meaning there will be no surface run off. Rainwater would run off surfaces such as roads because they are impermeable which means water can't soak into the ground, instead it gathers speed and joins other drains and eventually spills into a river.[3]

Small piles of sedimentary rock can occasionally build up in a river. This can be an obstacle therefore the river itself must avoid it and go around it. By doing this the river may speed up due to the fact that the water is being forced to go a different way and may be being forced to go into a smaller channel for a second. Variations in the river can mean that the speed of it may vary depending on the obstacle.

Figure 8: Reasons for varying river speed

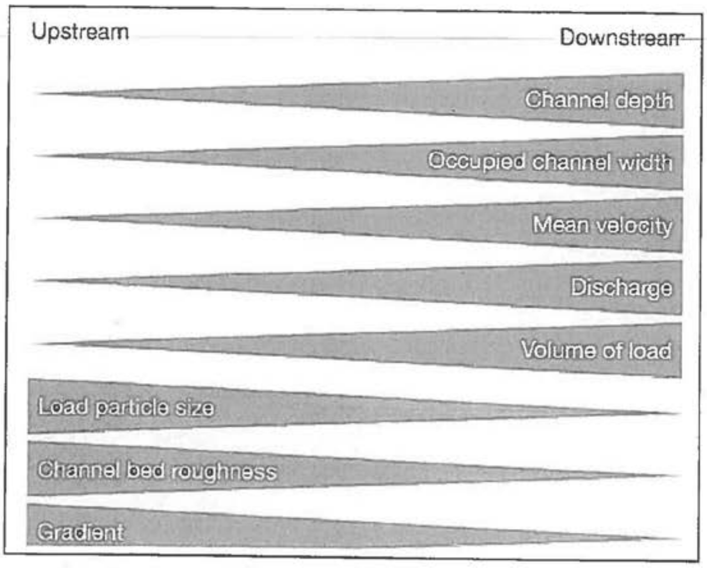
This small pile of rocks in the Glade Burn could affect the speed of the river because it means the water has an obstacle in which it has to avoid and try and find a way around if it doesn't stop the river flowing altogether. This therefore means then river will speed up as it approaches this small section of the river because the water has to be forced to go a certain way because of the disruption in the middle of the river.

[2] https://www.geography-fieldwork.org/rivers/river-variables.aspx
[3] http://www.acegeography.com/factors-affecting-river-discharge.html

2. Does river width increase with distance from the source?

The Bradshaw Model suggests that river width will increase with increasing distance downstream as seen in Figure 9 below.[4]

Figure 9: Bradshaw Model




When comparing river with and distance downstream, Spearman's Rank Correlation Coefficient was used to indicate the type of correlation between the two data sets, and whether there was any connection between them. Spearman's rank was used as it is the most reliable technique and has the least restraints on the type of data required e.g. data need not be grouped specifically and there is no restrictions on the values.

Figure 10: Spearman's Rank Carmichael Burn

| Width | Rank | Distance | Rank | D | d² |
|---|---|---|---|---|---|
| 4.5 | 2 | 100 | 1 | 1 | 1 |
| 4.25 | 1 | 200 | 2 | -1 | 1 |
| 4.9 | 3 | 300 | 3 | 0 | 0 |
| 5.42 | 6 | 400 | 4 | 2 | 4 |
| 6.1 | 8 | 500 | 5 | 3 | 9 |
| 5.2 | 4 | 600 | 6 | -2 | 4 |
| 5.38 | 5 | 700 | 7 | -2 | 4 |
| 5.63 | 7 | 800 | 8 | -1 | 1 |
| | | | | | Σd² = 24 |

$rs = 1-(6\ \Sigma d^2\ ) / n^3 - n$

$= 1-(144)/630$

$= 0.22857143$

$= \underline{0.77}$

[4] https://www.geography-fieldwork.org/rivers/river-variables.aspx

Figure 11: Glade Burn

| Width | Rank | Distance | Rank | D | d² |
|---|---|---|---|---|---|
| 3.45 | 6 | 100 | 1 | 5 | 25 |
| 4.57 | 8 | 200 | 2 | 6 | 36 |
| 4.42 | 7 | 300 | 3 | 4 | 16 |
| 3.4 | 5 | 400 | 4 | 1 | 1 |
| 3.33 | 4 | 500 | 5 | -1 | 1 |
| 2.43 | 2 | 600 | 6 | -4 | 16 |
| 1.92 | 1 | 700 | 7 | -6 | 36 |
| 2.68 | 3 | 800 | 8 | -5 | 25 |
| | | | | | Σd² = 156 |

rs = 1-(6 Σd² ) / n³ - n

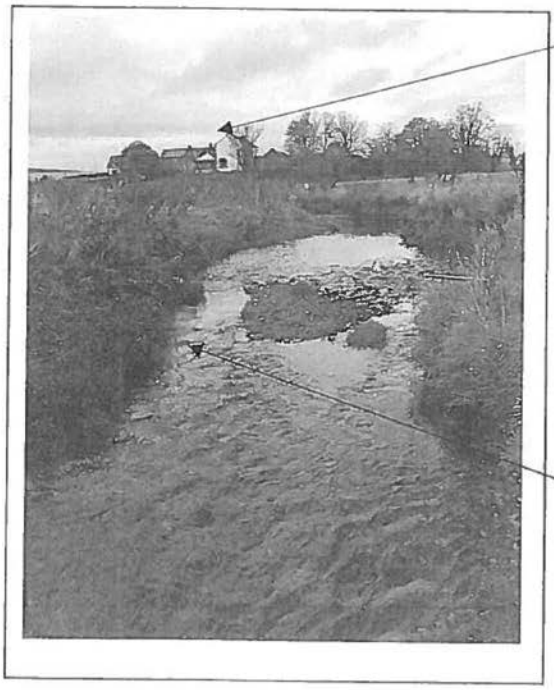
= 1-(156)/630

= 0.24761905

= 0.75

In Figure 10 on page 10 and Figure 11 above, the number of pairs is 8(n). Comparing our result to a table of critical values for Spearman's Rank we can see that the critical value for 95% level of significance is 0.05. The result demonstrated above for Carmichael Burn was 0.77 and for Glade Burn was 0.75, which is higher than the critical value of 0.738 and so shows a strong positive correlation. This additionally demonstrates that a relationship between the width and distance downstream exists on the Glade Burn and Carmichael Burn.

Figure 12: Glade Burn



Beside the Glade Burn there is a farm which means the land surrounding the river could be used for agricultural reasons. This could therefore have an impact on the width of the river depending on what the land is being used for.

The river may need to be manipulated to suit the area surrounding it. Perhaps something may be built and the river may have to change its course to adapt to its changing surroundings.

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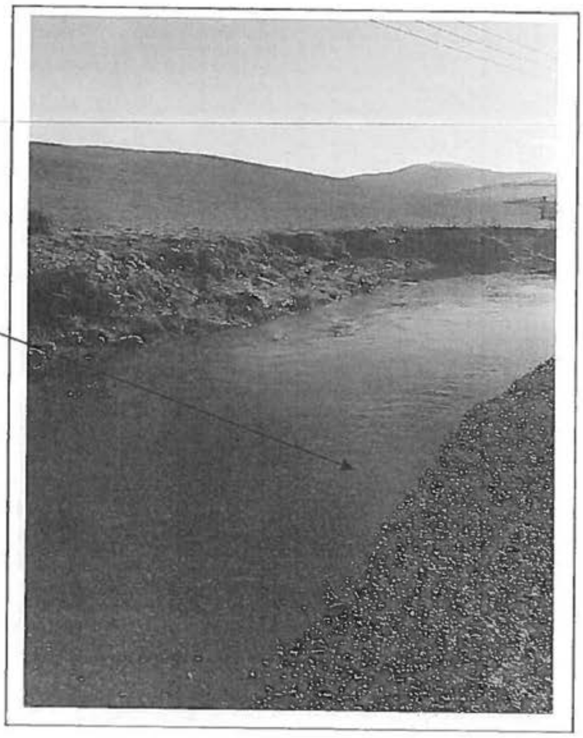
Figure 13: Carmichael Burn

In the Carmichael Burn there is an area filled only by small rocks and pebbles. These could have been deposited here due to the river flowing slower on the inside bend and not having enough energy to carry its load and over time it has built up and created a small area of sediment.

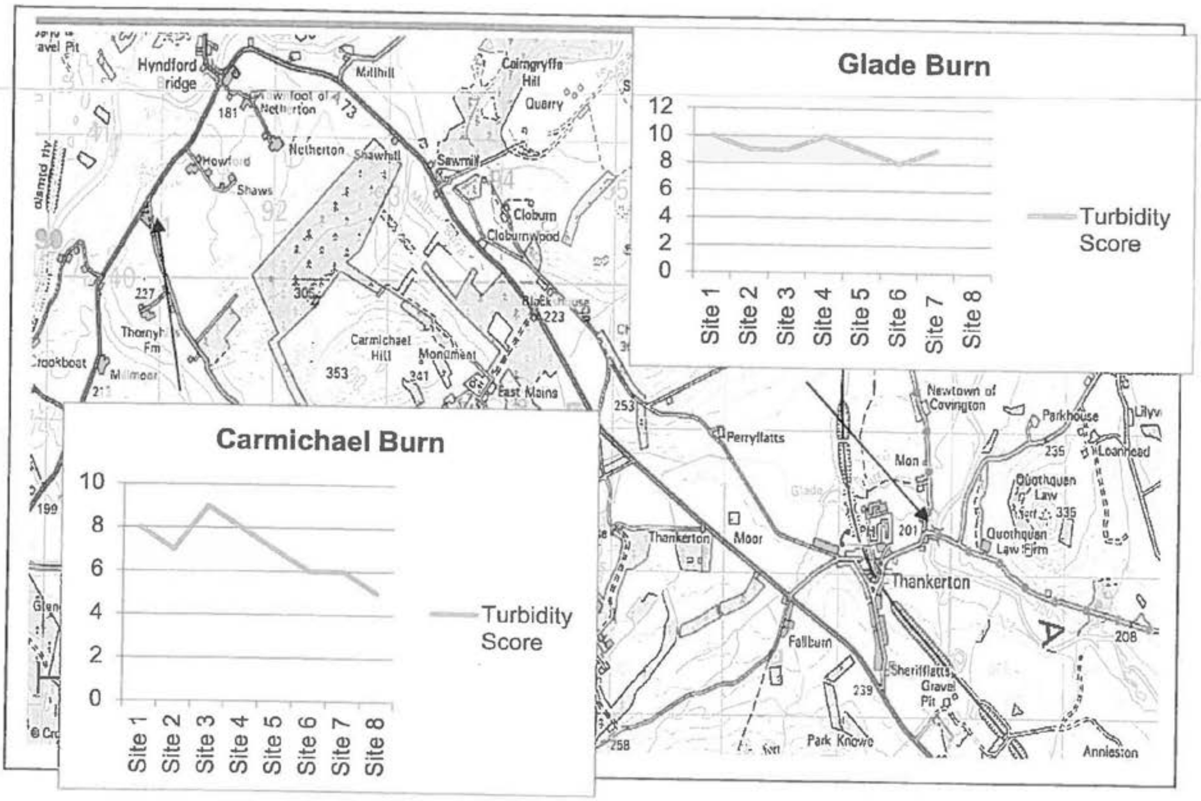


From my results I can see that as the river moves downstream and further away from the source that the river channel becomes wider. In both rivers it has been proven that there is a strong positive relationship between width and distance downstream. This is because as the river moves downstream it gathers more water[5] from surface run off and other tributaries forcing the river channel to widen to accommodate the large amounts of water.

[5] http://coolgeography.co.uk/A-level/AQA/Year%2012/Rivers_Floods/Channel%20characteristics/Channel%20Characteristics.htm

3. The turbidity of the river depends on the surrounding area.

Figure 14: River Turbidity Comparison




I have found that as the river nears the River Clyde and is coming to the end of its tributary the clarity of the water becomes worse. At my first few sites which were nearer the source of the river I scored the water here much higher in terms of turbidity. However as my sites got closer to the River Clyde I began to score both rivers lower due to the clarity of the water becoming worse. In both rivers there was a similar trend and that was the further away from the source the clarity of the water was affected.

My hypothesis 1 has been proven to be true, that turbidity is affected by land use around the river. When I visited both rivers I scored the turbidity of the water out of 10. To do this I scored each site a number out of 10 for the clarity of the water and at the end I took an average for each river. By doing this I could compare both rivers to find out whether they were similar or different in terms of the clarity of the water.

For the Glade Burn I got an average of 7 for the turbidity of the river and for Carmichael Burn I got average of 9. This proves that there is a relationship between the turbidity of a river and the land use around it.

As both tributaries neared the River Clyde the turbidity was similar in terms of the clarity of the water was not very good. It was very unclear and murky. This could be because as the river flows downstream into the lower course of its course it will have picked up sediment and rocks along the way and because the river has energy it will be able to carry its load and not deposit it. This therefore means the clarity of the water will not be as good as it was upstream.

From my results I can see that as the river gets deeper, the turbidity of the river gets worse. This could be because as the river comes through its upper and middle course it picks up more load such as rocks and silt. The increased erosion of river banks can also increase the turbidity of a river and may have a long term effect on a body of water.[6]

Therefore the second hypothesis for this RQ has been proven to be true, that as the river depth increases so does the turbidity of the river.

[6] http://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/

4: Does river depth vary across both streams with increasing distance downstream?

Glade Burn

Figure 15: Cross Section comparing river depth and width

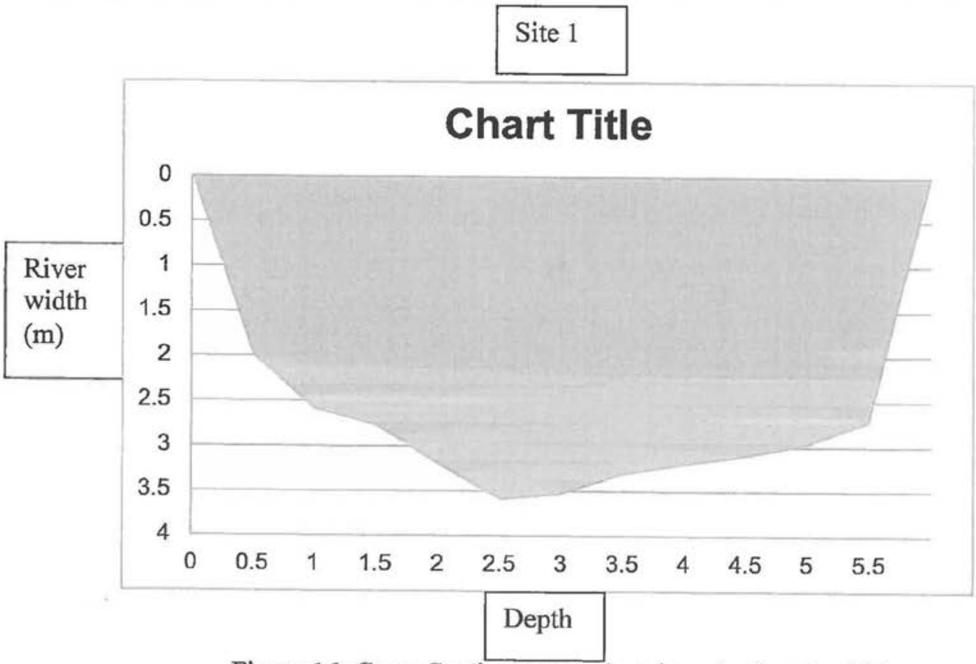



Figure 16: Cross Section comparing river depth and width

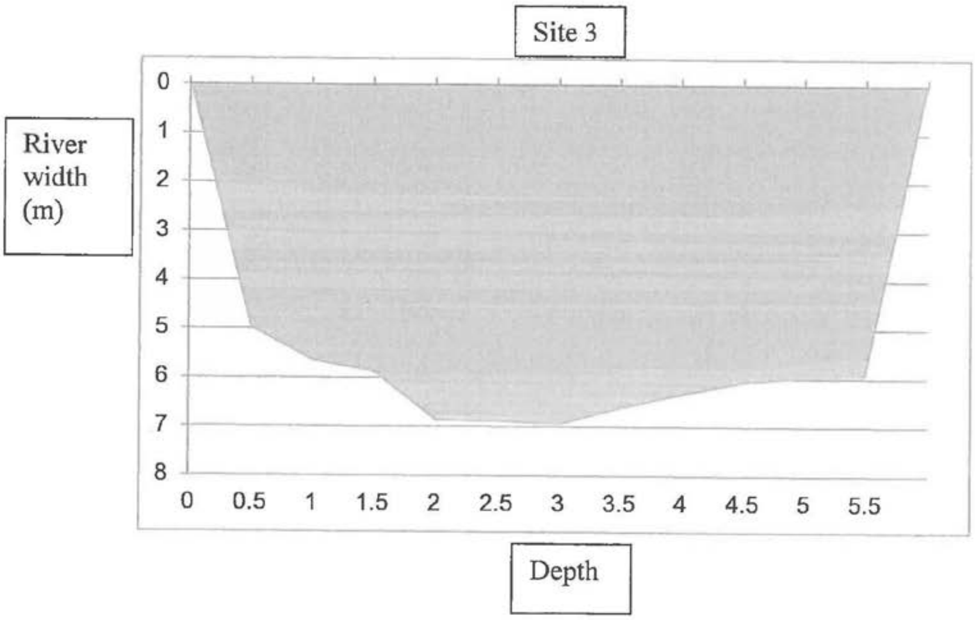
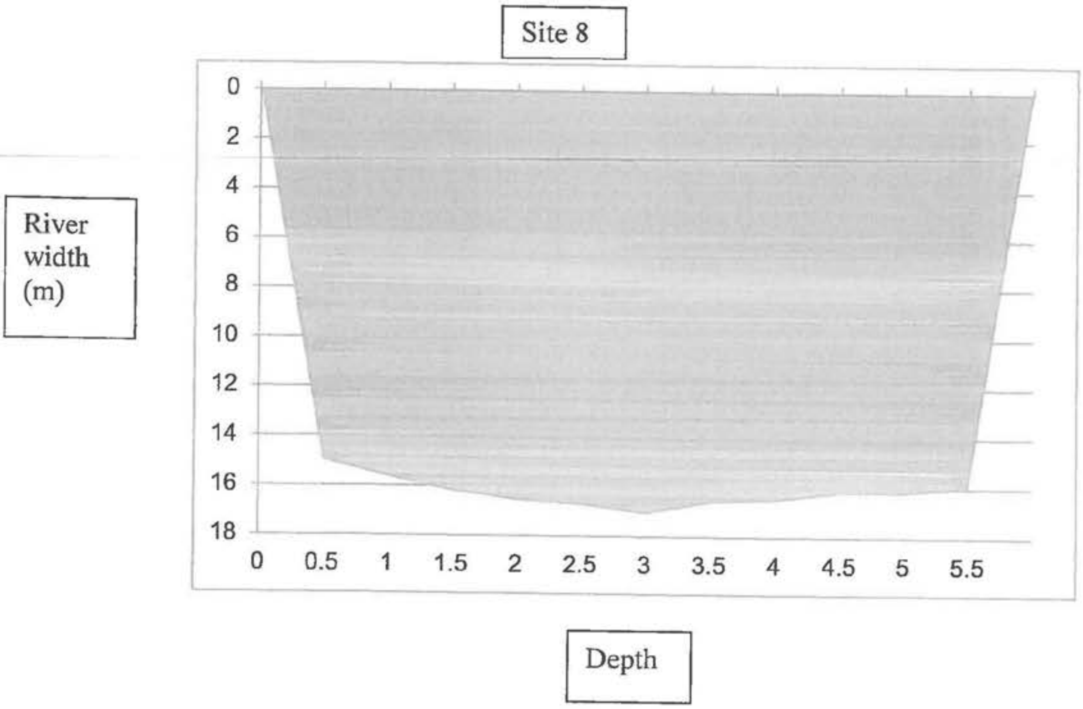


Figure 17: Cross Section comparing river depth and width




Carmichael Burn

Figure 18: Cross Section comparing river depth and width

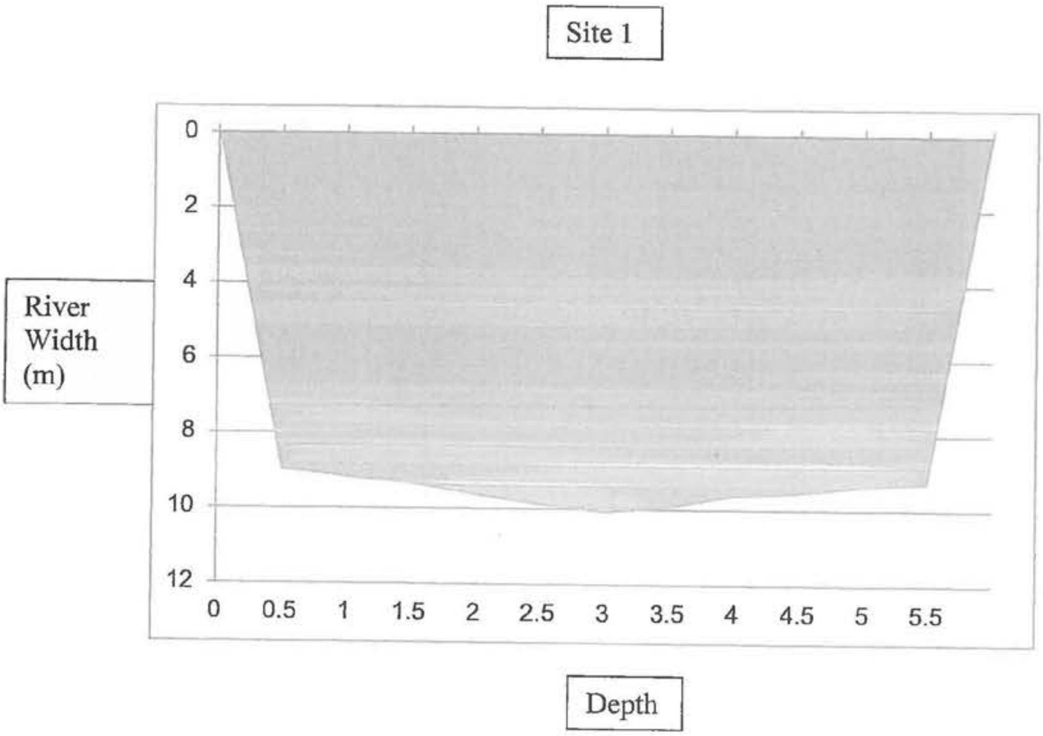


Figure 19: Cross Section comparing river depth and width

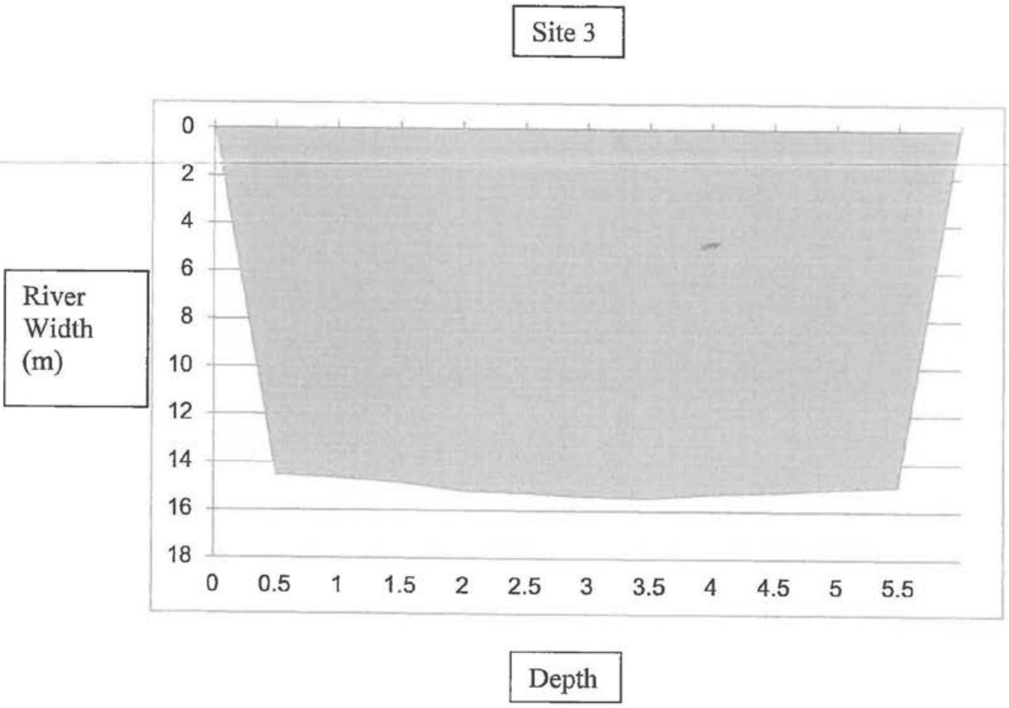



Figure 20: Cross Section comparing river depth and width

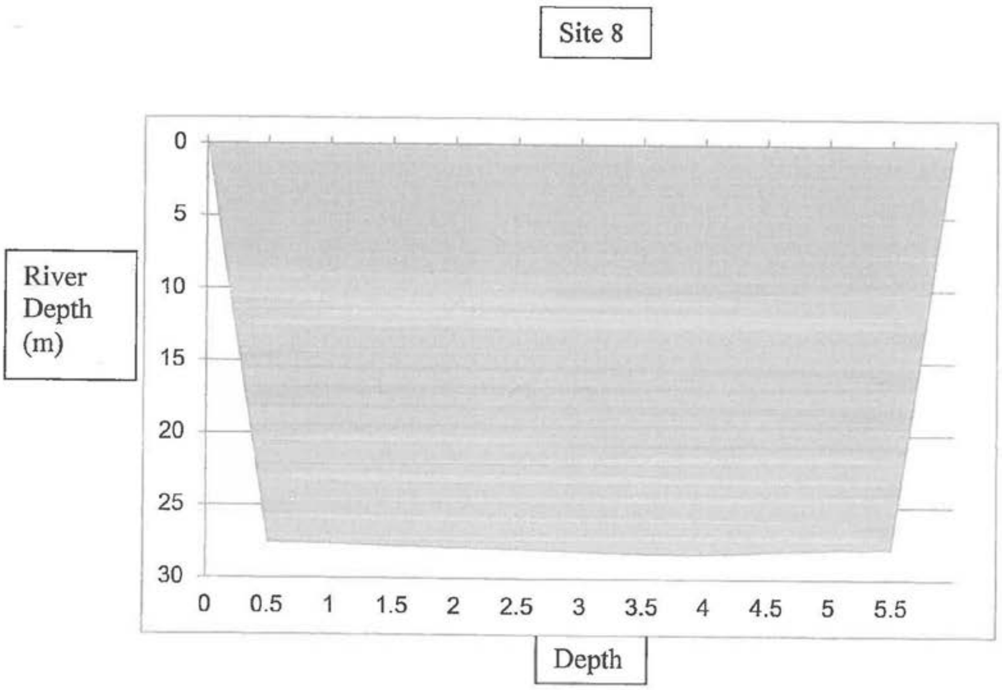


Figure 21: Spearman's Rank Glade Burn

| Depth | Rank | Distance | Rank | D | d² |
|---|---|---|---|---|---|
| 10 | 2 | 100 | 1 | 1 | 1 |
| 9.52 | 1 | 200 | 2 | -1 | 1 |
| 11 | 3 | 300 | 3 | 0 | 0 |
| 12.6 | 5 | 400 | 4 | 1 | 1 |
| 12.2 | 4 | 500 | 5 | -1 | 1 |
| 12.9 | 6 | 600 | 6 | 0 | 0 |
| 13 | 7 | 700 | 7 | 0 | 0 |
| 13.4 | 8 | 800 | 8 | 0 | 0 |
| | | | | | Σd² = 4 |

rs = 1-(6 Σd² ) / n³ - n

= 1-(4)/630

= 0.00634921

= 0.99

Figure 22: Spearman's Rank Carmichael Burn

| Width | Rank | Distance | Rank | D | d² |
|---|---|---|---|---|---|
| 11.54 | 2 | 100 | 1 | 1 | 1 |
| 10.35 | 1 | 200 | 2 | -1 | 1 |
| 15.7 | 4 | 300 | 3 | 1 | 1 |
| 15.6 | 3 | 400 | 4 | -1 | 1 |
| 18 | 5 | 500 | 5 | 0 | 0 |
| 18.9 | 7 | 600 | 6 | 1 | 1 |
| 18.87 | 6 | 700 | 7 | -1 | 1 |
| 19.1 | 8 | 800 | 8 | 0 | 0 |
| | | | | | Σd² = 6 |

rs = 1-(6 Σd² ) / n³ - n

= 1-(6)/630

= 0.00952381

= 0.99

In Figures 21 and 22 above, the number of pairs is 8(n). Comparing our result to a table of critical values for Spearman's Rank we can see that the critical value for 95% level of significance is 0.05. The result demonstrated above for both Carmichael and Glade Burns was 0.99, which is higher than the critical value of 0.738 and so shows a strong positive correlation. This additionally demonstrates that a relationship between river depth, width and distance downstream.

It is clear that river depth is related to river width and distance downstream. Figures 15-20 demonstrate that as a river moves downstream they get deeper and wider. The width and depth will increase as it moves further downstream due to erosion. The four types of erosion that can occur are corrosion, abrasion/corrasion, attrition and hydraulic action. Corrasion, Corrosion and hydraulic action will increase as you move further downstream due to the discharge increasing.[7]

[7] http://www.bbc.co.uk/schools/gcsebitesize/geography/water_rivers/river_processes_rev1.shtml

## Conclusion

Both of the rivers researched proved to be very different but had the typical properties a river should have. In textbooks and websites it states that as a river gets deeper its velocity should increase and from my research I have proved this to be true. As both rivers approach the River Clyde they pick up speed as they have gathered energy from further up the river. This therefore means that the river has enough energy to carry its load so it doesn't deposit any sediment meaning the river does not get shallower.

Although both rivers are similar, differences could be seen in depth, width, speed and deposition. All of these aspects put together contributed to each river being individual.

Similarly both tributaries as they approach the River Clyde increase in width. Carmichael Burn is slightly bigger than Glade Burn but shows the same properties. Both rivers get wider as they approach the end of their tributary and empty into the River Clyde. This is because as the river gets further away from its source it gains more water meaning the river sides need to become wider to accommodate the new mass of water.

According to the Bradshaw Model as a river moves further downstream it should become wider and deeper and its velocity should increase. As I investigated this theory in both rivers I found both rivers show these properties changing as they move downstream. By both of my rivers fitting this 'model' river it proves that there is a relationship between width, speed and distance downstream.

Water clarity according to my results can be related to the surrounding land use to a certain extent however it does not make a significant impact on it. From my research question I found that the Glade Burns water clarity was worse than Carmichael Burn and this may be due to the fact that there is a farm located next to the river. Therefore this hypothesis is true to a certain extent.

## Bibliography

Figure 1: http://digimapforschools.edina.ac.uk/dfs/schools
Figure1.2:http://digimapforschools.edina.ac.uk/dfs/schools

Figure 1.3: Information collected
Figure 1.4:Information collected
Figure 1.5:Information collected
Figure 1.6: Photos taken
Figure 1.7: Information collected
Figure1.8: Photos taken
Figure 1.9: Photos taken
Figure 2: Photos taken
Figure 2.1: Information collected

## Textbooks

Waugh, David (1995) *Geography: An Integrated Approach*, Thomas Nelson & Sons

## Internet Research

Fundamental of Environmental Measures:
http://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/

Cool Geography:
http://coolgeography.co.uk/A-level/AQA/Year%2012/Rivers_Floods/Channel%20characteristics/Channel%20Characteristics.htm

Geography Fieldwork:
https://www.geography-fieldwork.org/rivers/river-variables.aspx
https://www.geography-fieldwork.org/rivers/river-variables.aspx

Ace Geography:
http://www.acegeography.com/factors-affecting-river-discharge.html

BBC Bitesize
http://www.bbc.co.uk/schools/gcsebitesize/geography/water_rivers/river_processes_rev1.shtml
accessed March 2016