DETAILED SURVEYS AND RESTORATION PLANNING FOR TWO STREAMS IN THE ST. MARY'S RIVER WATERSHED

CAMPBELL'S BROOK & SUTHERLAND'S BROOK.

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ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

During three years of reconnaissance-level stream assessments two streams (Campbell's Brook; East Branch, St. Mary's River, and Sutherland's Brook; West Branch St. Mary's River) were identified as requiring greater detailed survey and assessment, and development of restoration plans. These brooks were surveyed in detail in late-August and September, 2011.

Campbell's Brook is a highly modified landscape and channel, including large amounts of bank armouring (rip-rap) and large gravel bars. The channel is dominated by riffle habitat. There is little riparian cover, obvious crossing of the stream by cattle, and overwidening of the channel. It is also notable by a lack of large woody debris. Substrate is large and indications are that the stream has considerable power of flow. Limiting factors in this stream are: (1) Lack of habitat diversity, (2) Reduction of use of upstream sections of this stream, due to access difficulties, (3) Lack of cover for protection from predators, (4) and likely also includes temperature extremes and ice scour. The purpose of restoration in this brook is to: (*i*) create habitat diversity to promote year-round use of this section of stream and allow access through the long riffle area to more appropriate habitat conditions upstream, and (*ii*) Provide cover to promote use of this area of stream. Rock weirs and boulder grouping are recommended to accomplish this.

Sutherland's Brook is low gradient with small substrate size, and high degree of meander. Much of the substrate is composed of organic material and silts. There is an abundance of fish cover in the form of undercut banks and large woody debris. Channel morphology is meandering and channel width quite consistent throughout the section. The channel is not overwidened, and riparian condition is good to excellent. The limiting factors to fish production in this stream are: (1) Loss of water in channel during low flow periods, (2) Low frequency of pools and domination by runs, and (3) low gradient and fine substrate. The purpose of restoration in Sutherland's Brook is to ensure fish passage during low flow conditions from the Highway bridge upstream. Paired deflectors are recommended to accomplish this.

Restoration of Campbell's Brook will be intensive and expensive due to the requirement of rockwork and machine time. In contrast, Sutherland's Brook restoration actions may easily undertaken with labour and hand tools. These two streams could have the required restoration activities take place on them in the same summer season. Future temperature monitoring of Campbell's Brook is recommended.

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1.0 INTRODUCTION

During three years of reconnaissance-level stream assessments, involving more than 30 streams (see Mitchell, 2010; 2011a) two of these streams were identified as requiring more detailed survey and assessment than the others, as well as development of restoration plans. These two were Campbell's Brook (East River, St. Mary's) and Sutherland's Brook (West Branch, St. Mary's). This report details these surveys undertaken in summer 2011, the results, and the consequent restoration plans.

2.0 STUDY AREA

The study area of this report includes two stream systems in the St. Mary's River watershed (Figure 1): (1) Campbell's Brook on the East Branch at Willowdale, and (2) Sutherland's Brook on the West Branch at Lower Caledonia.

Campbell's Brook: Campbell's Brook (confluence with East River, St. Mary's at 45^{o} 23' 44"N; 62^{o} 13' 20"W) is a 3rd order stream draining 29 km^{2} (Table 1). The lower 1,000 m of the brook are highly impacted by agricultural practices, having been extensively modified (channelized and rip-rapped) in the 1960s and 1970s. Upstream of this highly modified landscape the stream is in a forested valley with a history of forest harvesting in the area. Road density, as a proxy of development, is 0.79 km/km^{2} which is relatively low. Over the 10.6 km length of the longest branch, the elevation increases from approximately 75 m at the stream mouth to 230 m in the headwaters (Figure 2). Over this distance there are three "gradient sections", with a gradient of approximately 1.1 % in the lowest 4.2 km, then an increase to 3.6% from river km 4.2 to 7.2, followed by a decrease to a gradient of 1.0% to the headwaters. Overall mean gradient over the 10.6 km length is 2.5% (SD = 2.4%). Based on a pH survey by the SMRA conducted in 2009, the mean pH of Campbell's Brook is 6.8 (SD=0.18, range 6.45-7.02 N=8), which are some of the highest pH values in the St. Mary's River watershed (see Mitchell 2011b for more detailed analysis of this). Fish species known in Campbell's Brook, based on DFO electrofishing in 1983 and 1984, include American eel (*Anguilla rostrata*), Atlantic salmon (*Salmo salar*), brook trout (*Salvelinus fontinalis*), common shiner (*Notropis cornutus*), sea lamprey (*Petromyzon marinus*), and white sucker (*Catastomus commersoni*).

Sutherland's Brook: Sutherland's Brook (confluence with West Branch, St. Mary's at 45^{o} 16' 61"N; 62^{o} 15' 31"W) is a 3rd order stream draining 15.5 km^{2} (Table 1). The landscape of this stream has had a history of forest harvesting in the area. Road density, as a proxy of development, is 0.85 km/km^{2} which is relatively low. Over the 15.2 km length of the longest branch, the elevation increases from approximately 60 m at the stream mouth to 170 m in the headwaters. Over this distance the gradient remains quite constant (Figure 2), with an overall mean gradient of 0.91% (SD = 0.46%). Based on water quality data from Farmer et al. (1988) and Hart-Buckland Nicks (1995), Sutherland's Brook has a mean pH of 5.75 (SD=0.44, range 5.3-6.5 N=14). Fish species suspected present in Sutherland's Brook, based on DFO electrofishing of Indian Man

Brook[1], include American eel, Atlantic salmon, brook trout, common shiner, sea lamprey, white sucker, creek chub (*Semotilus atromaculatus*), lake chub (*Couesius plumbeus*), rainbow smelt (*Osmerus mordax*), unidentified dace[2], and unidentified shiner[3].

Table 1: Selected geomorphic attributes of Campbell's Brook and Sutherland's Brook, St. Mary's River watershed. Information derived from NTS 1:50,000 scale topographic map 11E/08.

	Campbell's Brook	Sutherland's Brook
Stream order	3rd	3rd
Confluence with St. Mary's River	45° 23' 44"N; 62° 13' 20"W	45° 16' 61"N; 62° 15' 31"W
Drainage area (km^2)	29	15.5
Elevation range (m)	~75 - 230	~60 - 170
Change in elevation (m)	155	110
Length of longest branch (km)	10.6	15.15
Length of first order streams (km)	21.1	10
Length of second order streams (km)	1.1	6.5
Length of third order streams (km)	4.05	6.2
Total length of streams (km)	26.25	22.7
Drainage density (km/km^2)	0.905	1.464
Length of roads (km)	23	13.15
Road density (km/km^2)	0.793	0.848

[1] There are no data on electrofishing of Sutherland's Brook, but extensive electrofishing in Indian Man Brook is expected to be representative of Sutherland's Brook as the two systems are very near to each other (i.e. confluences within 3.0 km straight line distance). DFO electrofishing occurred in Indian Man Brook annually in 1984-1986, 1990-1992, 1994-2000, 2002-2007, and 2009-2010.
[2] Unidentified dace likely either northern redbelly dace (*Chrosomus eos*) or pearl dace (*Semotilus margarita*)
[3] Unidentified shiner likely common shiner or golden shiner (*Notemigonus crysoleucas*)

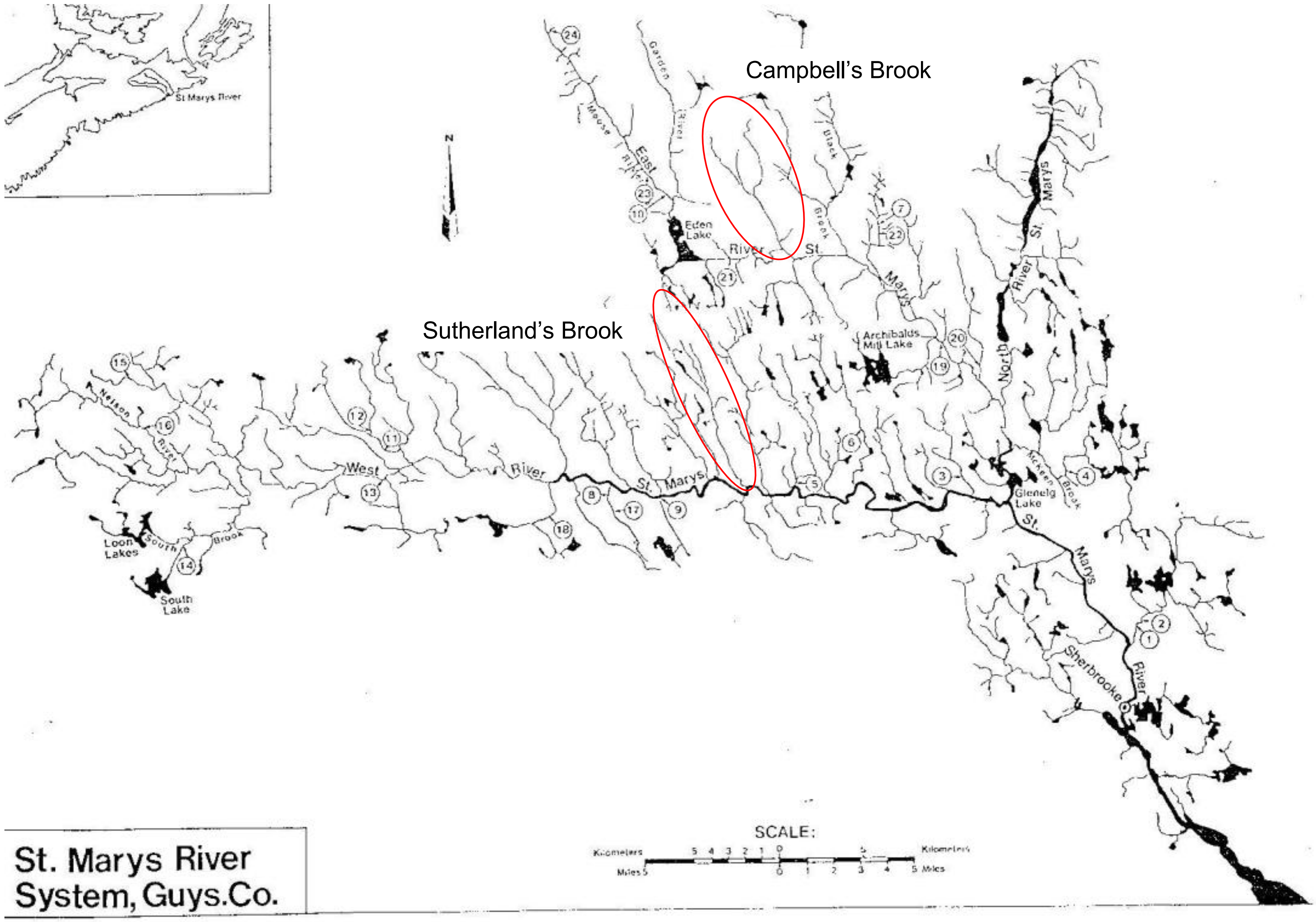


Figure 1: St. Mary's River watershed showing two systems examined here (circled), Campbell's Brook and Sutherland's Brook.

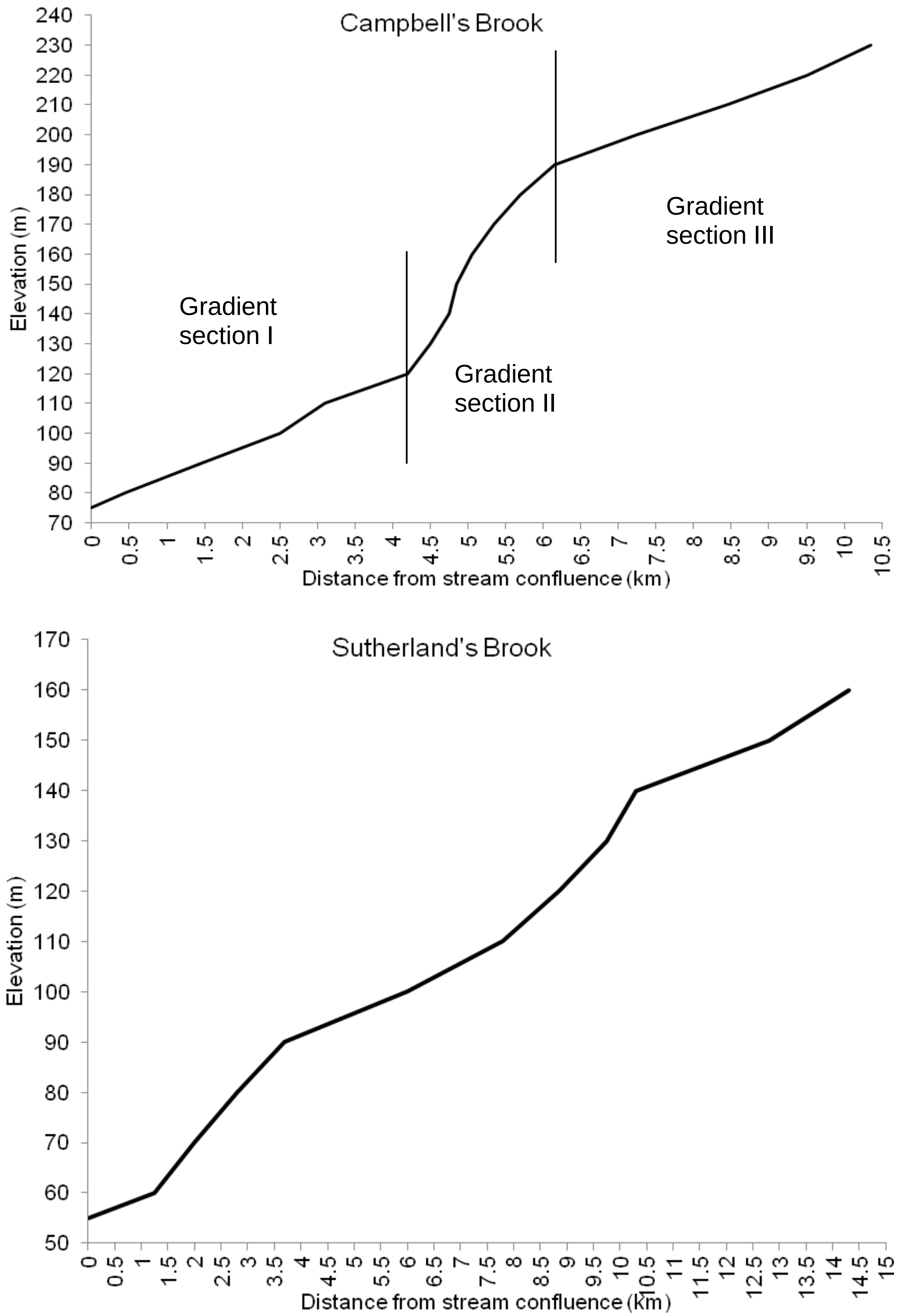


Figure 2: Longitudinal profiles of Campbell's Brook and Sutherland's Brook from confluence with St. Mary's River upstream along longest branch shown on 1:50,000 scale NTS map.

3.0 METHODS

Campbell's Brook was surveyed on three days (Aug. 26, Sept. 16, Sept. 23, 2011) and Sutherland's Brook on a single day (Sept. 28, 2011). For each brook, the length to be surveyed was divided into contiguous 50 m long sections and each section surveyed individually. Cross channel transects at the downstream end of each section, except the upstream-most section in which transects were done at both upper and lower ends, measured channel (Bankfull) width, wetted width, depths and bank heights, resulting in transects spaced every 50 m. Gradient of each 50 m section was determined by transit and rod. Stream length, compass bearings, and lengths of habitat types (run, riffle, pool) were recorded within each section for mapping purposes. Substrate was assessed using two methods (visual estimates of percent cover and Wolmann pebble count) in Campbell's Brook, and only by visual estimate of percentage cover in Sutherlands Brook. Substrate visual estimates were done within each section and Wolmann pebble counts (Campbell's Brook) in every 5th section (i.e., Section 5, 10, 15, 20, and 25). Large and small woody debris (LWD and SWD) presence and abundance were recorded. Representative photographs were taken of each section.

4.0 RESULTS AND DISCUSSIONS

Campbell's Brook:

Site Description

The surveyed section of Campbell's Brook between 250 and 1,100 m is highly modified. There is extensive rip-rapping used for bank protection (approximately 500 m linear length of rip-rap on alternating banks) imparting to the channel a limited meander or sinuousity (Table 2, Figure 3). This channel modification has significantly impaired natural channel function as evidenced by the dominance of a single habitat type (riffle) over this modified section. Riffle accounts for 65% of total linear habitat and run for the remaining 35% (Table 2). Riparian condition is also highly modified with little to no overstream vegetation and isolated stands of trees providing shade (Figure 4). Cattle use of the surrounding fields is apparent and there are five identified cattle fords crossing the stream. The channel is overwidened by approximately 30 % over that calculated based on drainage area (Table 2). Upstream of the modified section, the stream flows through an intact riparian forest but exhibits continued channel straightening (likely due to historical log driving?); indeed it appears to have lower sinuosity upstream than in the modified section. Riffles continue to dominate and substrate size is similar to that within the modified section. Downstream of the modified section, there is again an intact riparian condition of young forest, and meander has increased over the 250 m between the downstream end of the agricultural fields and the confluence with the East Branch, St. Mary's River.

Further evidence of the impact of channel modification is the complete lack of functional LWD throughout the lower kilometre of brook. The first piece of functional LWD encountered was in Section 20 (between 950-1,000 m upstream of the confluence). Upstream of that are uncommon and isolated pieces of LWD and one small debris accumulation on river left. Debris is likely readily transported out of this area of Campbell's Brook due to lack of complex channel morphology and the action of ice. Individual 50 m section gradients were quite similar along the 1,250 m length surveyed with a mean gradient of 0.91% (SD=0.31%, range 0.32-1.80%; N=24)

Table 2: Channel and habitat characteristics of Campbell's Brook and Sutherland's Brook as measured in 2011.

	Campbell's Brook (1,250 m)	Sutherland's Brook (500 m)
Habitat type distribution		
Percent run	30.0%	60.5%
Percent pool	3.5%	7.0%
Percent riffle	64.8%	8.4%
Percent run/pool	1.6%	10.8%
Percent run/riffle	--	13.2%
Mean measured channel width	15.5 m (SD=5.70 m); N=25	5.81 m (SD=1.01 m); N=11
"Appropriate" channel width [a]	11.2 m	8.9 m
Sinuosity [b]	1.11 (borderline straight/sinuous)	1.81 (meandering)
Substrate (visual estimates)		
% fines	mean=5.62; SD=2.24; N=24; range=0-10; median= 5	mean=37.0; SD=9.77; N=10; range=20-50; median= 7.5
% small gravel	mean=19.37; SD=7.27; N=24; range=5-30; median=20	mean=36.5; SD=7.47; N=10; range=25-50; median=35.0
% large gravel	mean=22.5; SD=7.07; N=24; range=10-35; median=22.5	mean=23.0; SD=4.22; N=10; range=20-30; median=20.0
% small cobble	mean=22.10; SD=5.5; N=24; range=10-35; median=22	mean=1.9; SD=1.73; N=10; range=0-5; median=2.0
% large cobble	mean=22.5; SD=6.08; N=24; range=15-35; median=20	mean=1.0; SD=0.94; N=10; range=0-2; median=1.0
% boulder	mean=7.3; SD=4.16; N=24; range=5-20; median=5	mean=0.9; SD=1.73; N=10; range=0-5; median=0.0
% bedrock	mean=0.0; SD=0.0; N=24; range=0.0-0.0; median=0.0	mean=0.0; SD=0.0; N=10; range=0.0-0.0; median=0.0

[a] = Appropriate channel width based on a watershed area from a relationship of stream width to watershed area of Width (ft) = 14.73 * Area (mi. sq.)$^{0.38}$ based on a regional assessment of streams from the eastern US as reported by Ohio Department of Natural Resources (2005).

[b] = The degree of meandering of the river per section was quantified by a "Sinuousity Index" calculated as river length (km) divided by the straight line distance (km) between upstream and downstream ends of the section. A value of 1.0 indicates a straight channel and increasing index values indicate increasing degrees of meandering. A sinuosity index of 1-1.5 indicates a sinuous pattern, while an index of 1.5-4.0 indicates a meandering morphology (Mount, 1995).

(Figure 5). There is a change in elevation of 11.4 m over the 1,250 surveyed distance. Mean depth across 26 measured transects was 17.6 cm (SD=0.04). This is low variation (Coefficient of Variation= 22%) in depth among transects, indicating they are all very similar in being shallow. Cross section transects are presented in Appendix 1.

Within Campbell's Brook, visual estimates indicate that the substrate is predominately and equally distributed among small gravel, small cobble and large cobble (Table 2) with each of these three classes representing means of 22% of the substrate. Quantitatively, from the Wolmann pebble count, median particle size (D_{50}) is 12-14 cm among five sampled sections (Figure 6). Cobble[4] (small and large; size range 64-256 mm) comprises 76% of the substrate averaged across the five pebble counts (SD=8.1%), with boulder and large gravel each comprising, on average, 11%-12%. The distribution of substrate is remarkably uniform, with the possible exception of Section 5 which departs at the upper size range from all other samples. Section 5 has a lower gradient (0.52%) than the other four samples (0.71%-1.08%), but indicates a greater abundance of large material in this section. It must be borne in mind that pebble counts are biased toward larger size substrate and do not take into account small (fines, sand) substrate. But the visual estimates corroborate the pebble counts showing a large substrate dominance.

Limiting Factors (Campbell's Brook)

The limiting factors to fish production in this stream are:

- Lack of habitat diversity (i.e., pools and runs). The existing condition would favour those species that prefer riffles, but the lack of pool habitat to retreat to during high or low flows, or extreme temperatures, minimize the year-round use of this habitat. This is true throughout the 1,250 m surveyed.
- The lack of pool and run type habitat over the long distance likely reduces use of upstream sections of this stream, due to access difficulties. Only strong swimmers, well adapted to riffle habitat, would easily negotiate the kilometre of dominantly riffle habitat. Thus, this section of Campbell's Brook may retard use of upstream sections by fish from the East Branch, St. Mary's River.
- Lack of cover for protection from predators. Existing cover is only in the form of boulder and cobble; there is no large woody debris or undercut banks, and very little deep water to retreat to. This is particularly problematic in the 850 m of modified stream; less so upstream and downstream of that area.
- Temperature is likely a limiting factor in summer, as direct solar insolation on this unshaded stream likely elevates summer temperature. This is exacerbated by the south-facing aspect of this stream providing direct solar insolation during the warmest parts of the day and year. This is likely a major issue through the modified section and downstream to the confluence.
- Ice scour is likely a limiting factor to this stream. Signs of ice scour were noted 1.0 to 1.5 m above the water surface. The lack of LWD is likely a function of removal in spring by ice rather than by freshets.

[4] Substrate sizes follow the Wentworth particle size scale, with small gravel being 2-16 mm, large gravel 16-64 mm, cobble 64-256 mm, and boulder >256 mm.

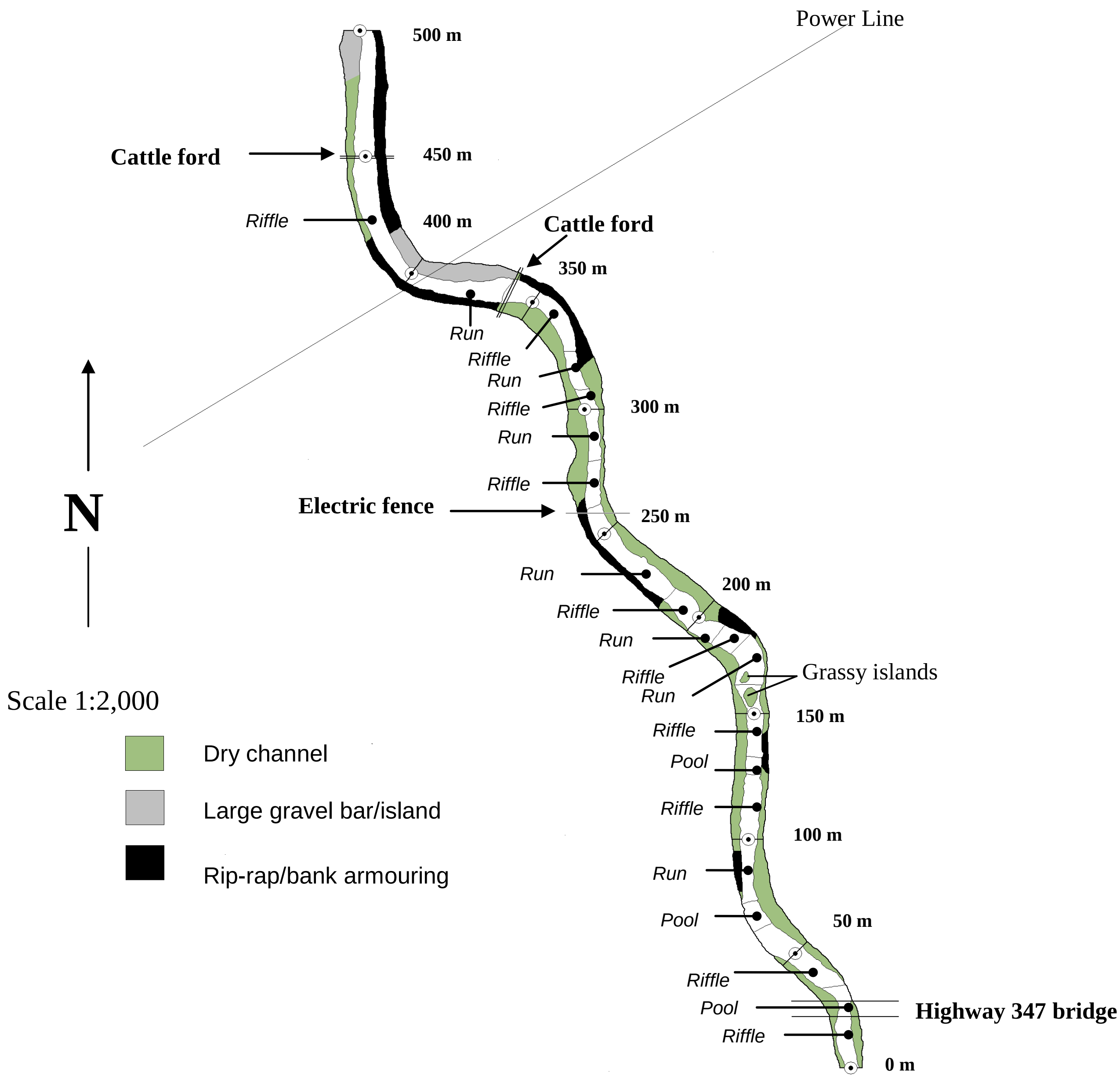


Figure 3(A): Map of Campbell's Brook based on field survey August-September, 2011 showing habitat distribution and key channel features. Map shows Campbell's Brook from confluence with East River, St. Mary's (0 m) upstream for a distance of 500 m.

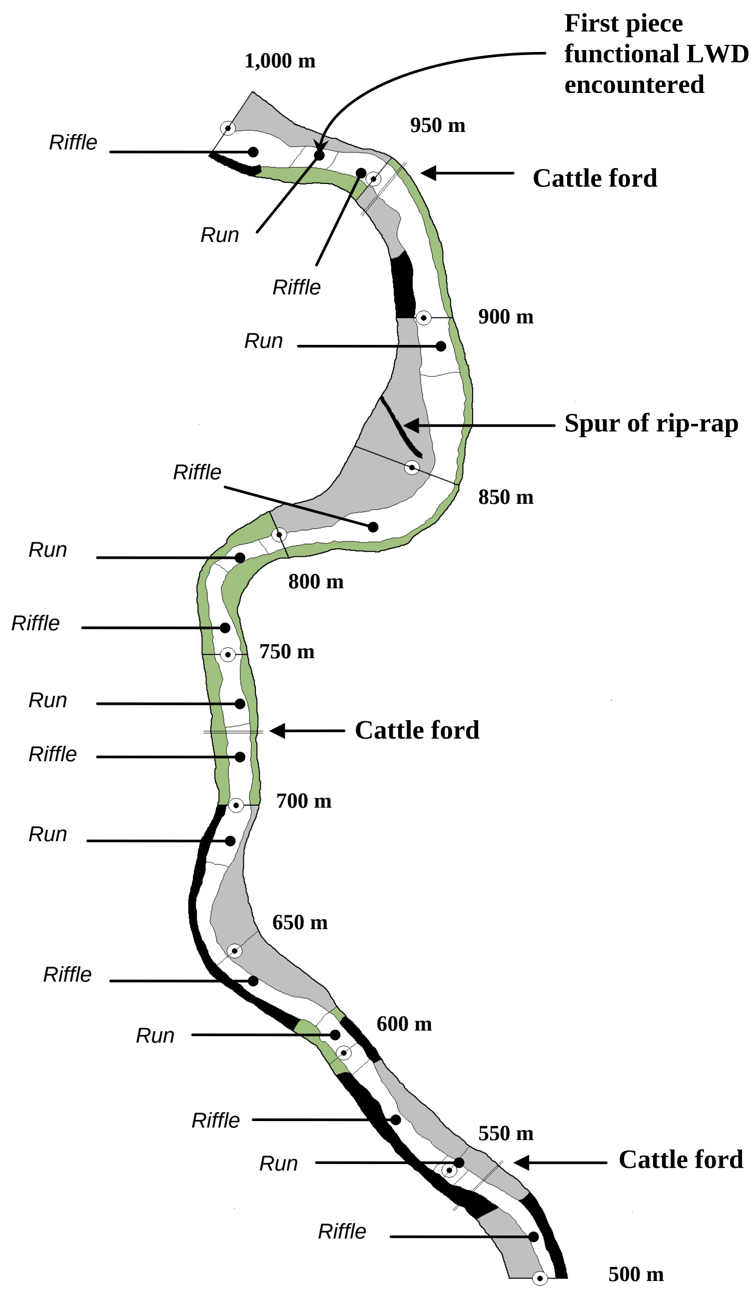


Figure 3(B): Map of Campbell's Brook based on field survey August-September, 2011 showing habitat distribution and key channel features. Map shows Campbell's Brook from 500 m to 1,000 m.

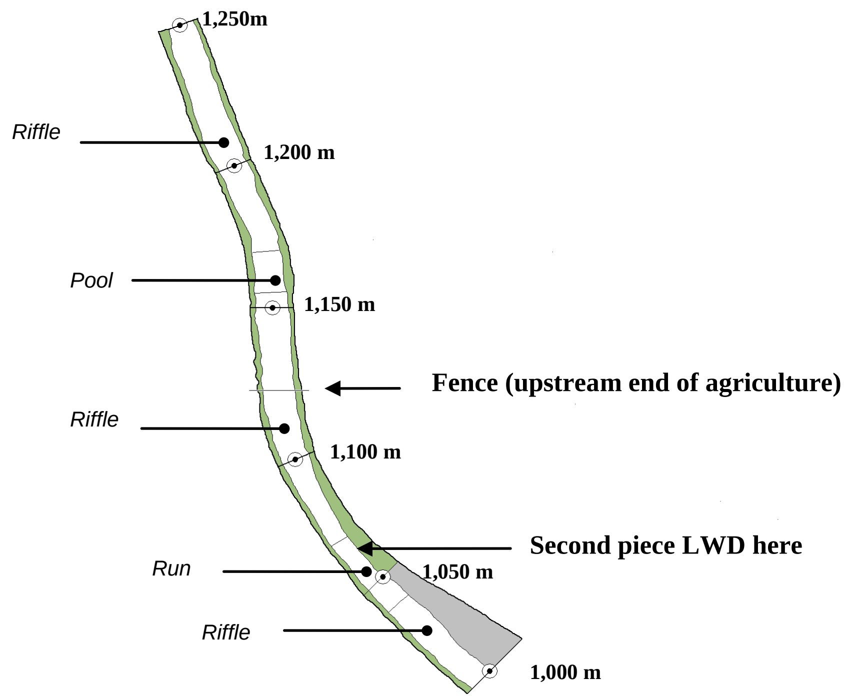
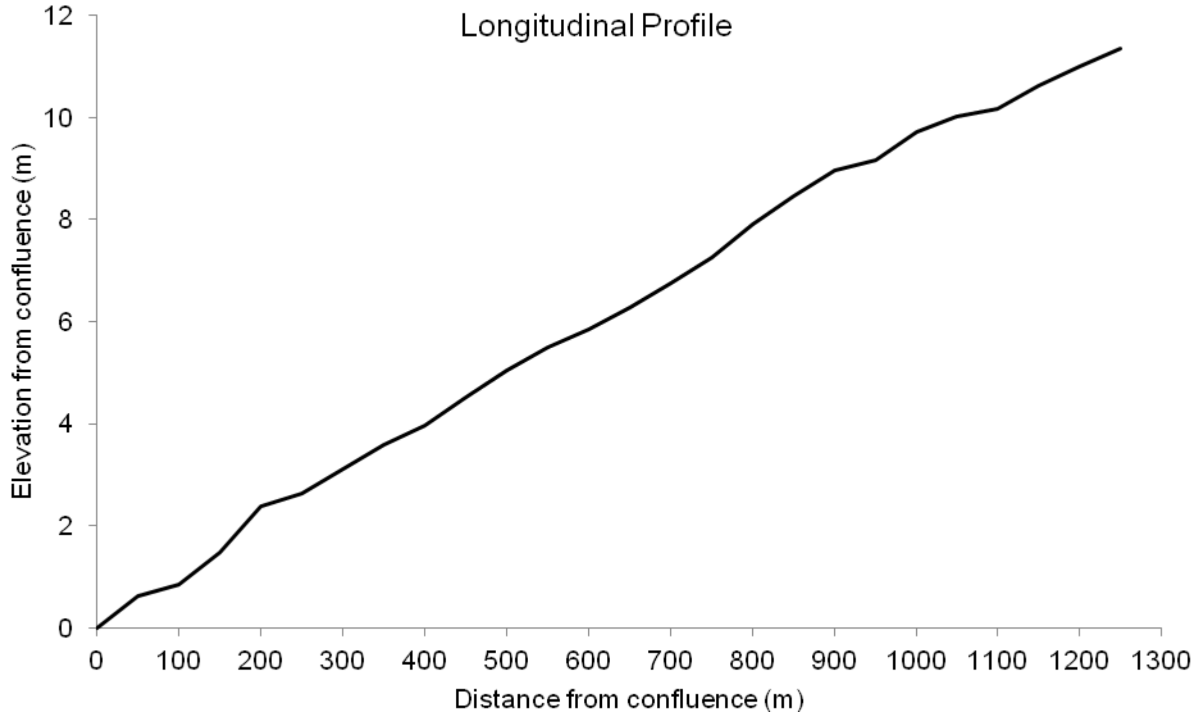


Figure 3(C): Map of Campbell's Brook based on field survey August-September, 2011 showing habitat distribution and key channel features. Map shows Campbell's Brook from 1,000 m to 1,250 m.

Figure 4: Aerial view of Campbell's Brook from Google Earth illustrating large gravel bars, road access to stream, and sporadic presence of riparian forest



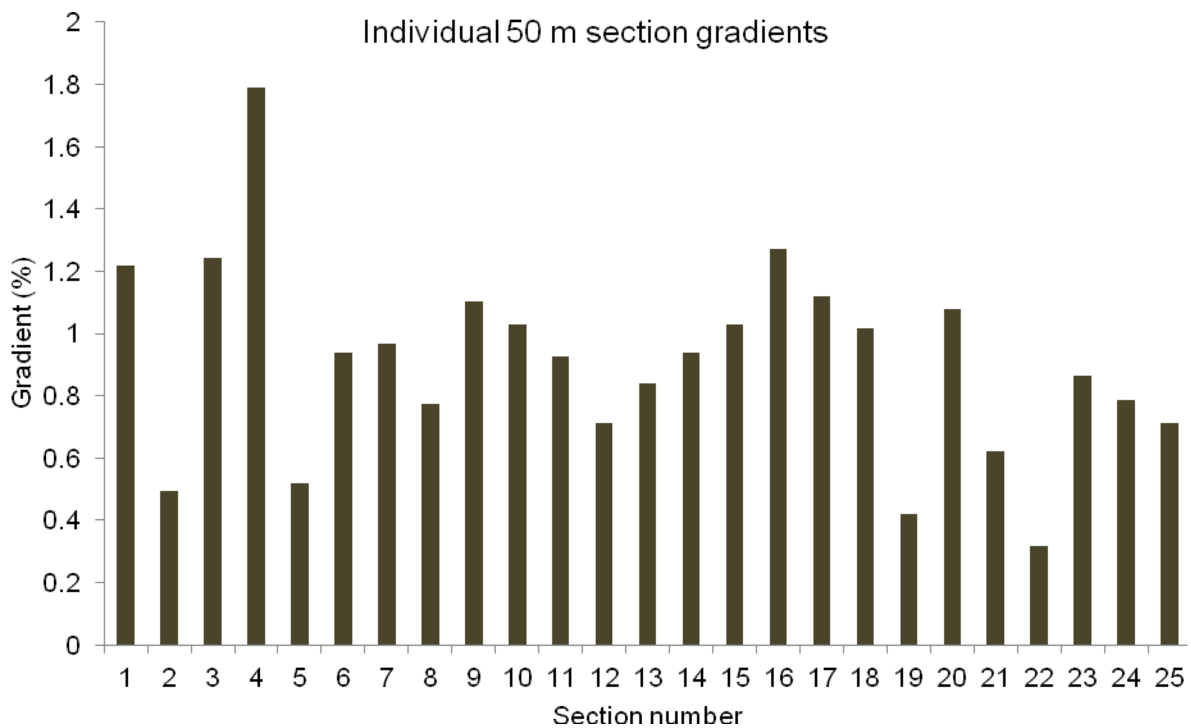


Figure 5: Longitudinal profile and individual 50 m section gradients for 1,250 m of Campbell's Brook surveyed in 2011.

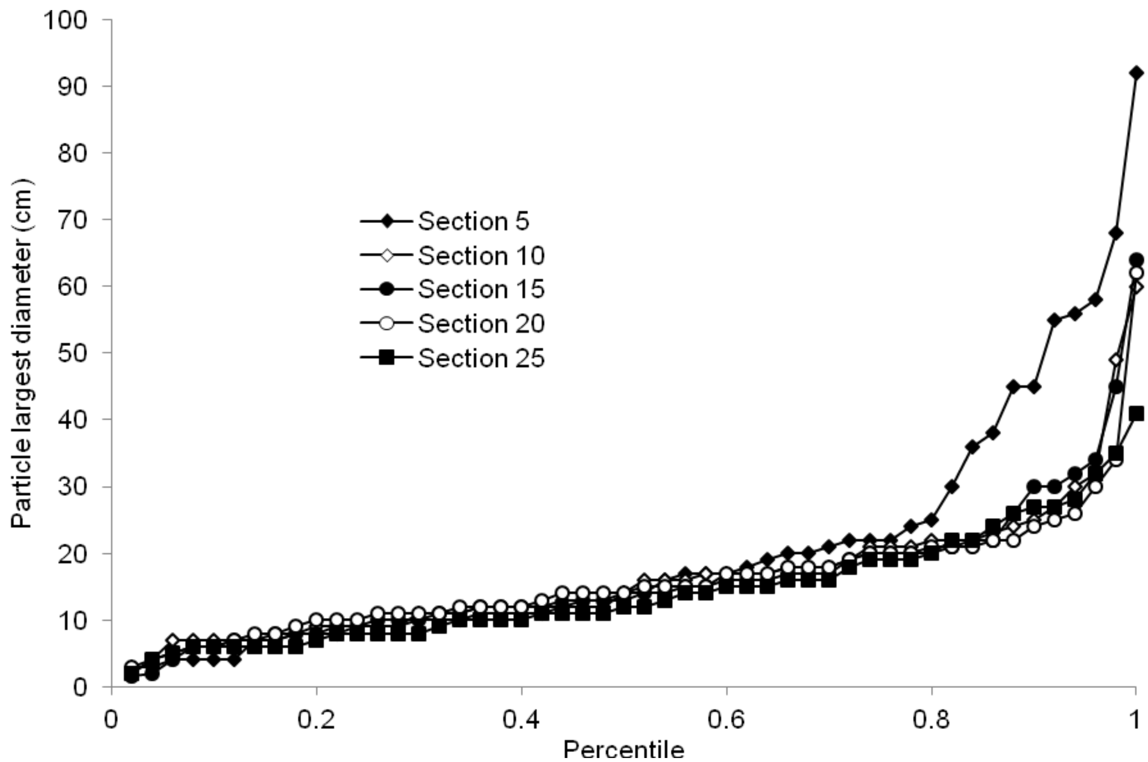


Figure 6: Frequency distribution of substrate particles in five sections (Section 5, 10, 15, 20, 25) of Campbell's Brook, 2011. Diameter of the largest axis of the stone was measured for 50 stones in each section in accordance with Wolmann pebble count methodology.

The stream flows through cattle pasture, but impacts to the stream from these animals is apparently not significant given the few cattle in the area, and the few isolated fords. Given the south-facing and dominance of shallow riffle, allowing excellent sunlight penetration of the water, the lack of extensive algal growth suggests that any nutrient enrichment from cattle feces is within the absorption capacity of the stream. Nutrient enrichment is not occurring in Campbell's Brook due to the cattle use

Purpose of restoration

The purpose of restoration in Campbell's Brook is to: (*i*) create habitat diversity to promote year-round use of this section of stream and allow access through the long riffle area to more appropriate habitat conditions upstream, and (*ii*) Provide cover to promote use of this area of stream.

Campbell's Brook Restoration Plan

The principal issue with this channel is the dominance of riffles and lack of structural diversity (cover). The implied power with which the water or ice flow through here, as evidenced by large substrate and lack of LWD, suggests that structures need to be designed to withstand high forces. For these reasons, two types of physical restoration are recommended for Campbell's Brook: (1) rock sills/weirs, and (2) boulder groupings.

Rock sills or weirs are used to locally deepen the channel by forming a pool downstream of the weir. Smart (1997) provides illustrations of interesting rock work (rock vortex and horseshoe weirs) which would be appropriate in Campbell's Brook. Eight rock weir structures should be constructed, approximately every 100 m along the channel within the agricultural impacted area (Figure 7). The 100 m distance is determined as six times the channel width of 16 m. A 16 m channel width is used in place of the "natural" 11 m due to the channel having adapted to this width in response to the hard banking (rip-rap). Unless most of this rip-rap is removed, the channel through this section will maintain its current morphology, including width, and so this appears the appropriate design width. Access along this section of the stream for machinery is excellent but will require landowner permission and approval. An advantage to Campbell's Brook is that there is such an abundance of rip-rap that selective removal from some of the armoured areas (particularly the apparently superfluous rip-rap spur at 850 m) will provide abundance of construction material.

Boulder groupings are used to provide cover for fish and to break up flow to provide resting areas. It is recommended that boulder groupings of 3-5 boulders per grouping be placed at mid points between the rock weirs (i.e., the boulder groupings themselves effectively at six channel width separations (Figure 7). These boulder groupings will also, over time, hopefully collect and retain some LWD and SWD moving down the channel.

Temperature regulation by riparian planting is not within this plan due to stream size and lack of adequate planting areas. The stream is large at this point, requiring more than planting of shrubs and alders to allow shading of the stream and much of the streambank condition is either rip-rap or large, unvegetated, gravel bars, which are not suitable for planting. Where tree growth is possible there are already existing, isolated and low density, stands of mature trees, providing some shading. Riparian planting may be a follow up restoration technique after the in-stream work but the need should be clearly demonstrated before this conducted (*Recommendation #1*).

Effects of ice need to be considered in all restoration. Thus, the use of rock weirs and boulder placement. These should be able to withstand effects of ice.

It is acknowledged that the channel is overwidened relative to a natural channel for this drainage area. However, there are already large bars on the inside of bends acting to narrow the channel, particularly against the unmoving rip-rap on the opposite side. The natural processes correcting the overwidening are at work and it is not obvious that further human intervention would significantly increase rate of recovery. Thus, channel overwidening in this stream is not being treated within the restoration plan.

Budget for Campbell's Brook Restoration

Below is a preliminary budget. Costs are rough estimates, not based on quotes. A more refined budget will be required prior to seeking funding.

Total estimated cost for proposed restoration: **$15,748**, broken down as:

Cost Component	Rate	Total Cost
Manpower		
Technical expertise/advice (NSLC Adopt-a-stream)	2 days at $300/day	$600
Project management (SMRA) (Initial landowner contact/liason; layout of site, monitoring of activity; reporting and documenting	10 days @ $300/day	$3,000
Travel (Project manager)	400 km (80 km/d * 5 days) @ $0.37/km	$148
Equipment		
Heavy equipment (backhoe or excavator) [a]	$1,200/day for 5 days	$6,000
Materials		
Assume all stone on site (rip-rap)		$00.00
Assume require rock [b]		$6,000
Total		**$15,748**

Note that if available rock on site is available for use, cost will be significantly reduced.

[a] = This estimate is based on $150/hr, based on estimates of $95/hr for backhoe and of $115 to 180/hr for excavator
[b] = Estiamte based on 250 metric tonnes at $23.00/metric tonne

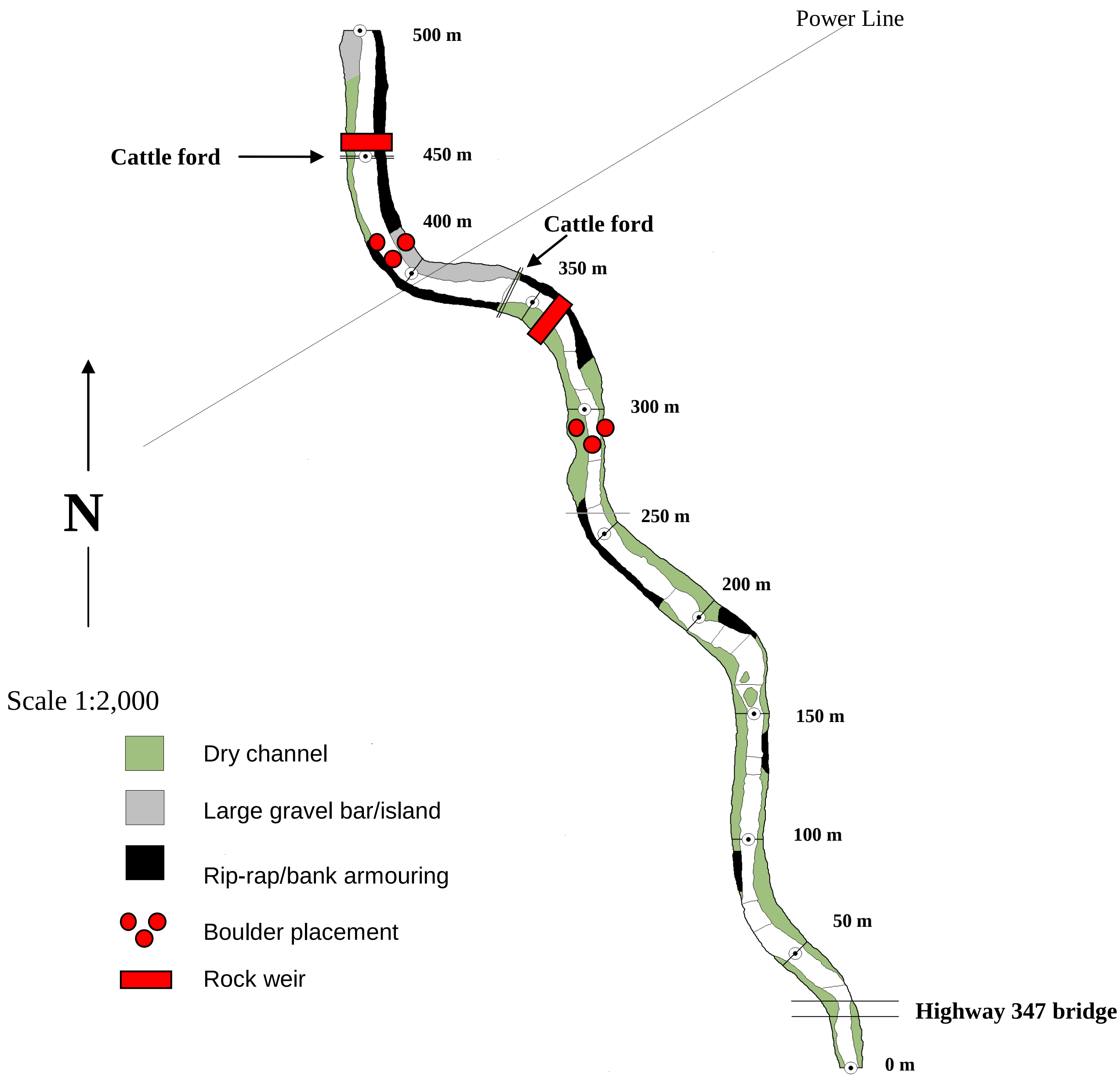


Figure 7(A): Conceptual diagram of restoration (eight of each of rock weirs and boulder groupings) in Campbell's Brook. Map shows Campbell's Brook from 0 m (confluence with East Branch, St. Mary's) to 500 m.

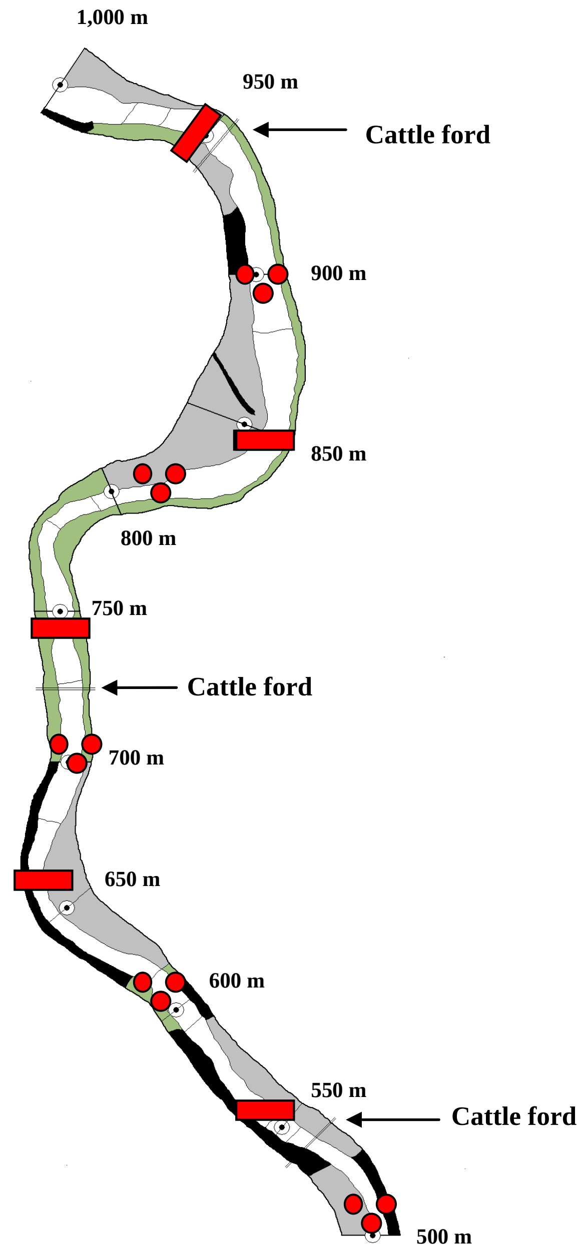


Figure 7(B): Conceptual diagram of restoration (eight of each of rock weirs and boulder groupings) in Campbell's Brook. Map shows Campbell's Brook from 500 m to 1,000 m.

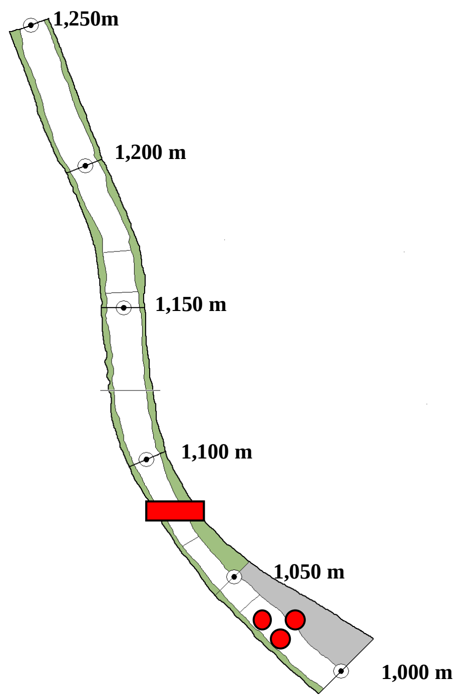


Figure 7(C): Conceptual diagram of restoration (eight of each of rock weirs and boulder groupings) in Campbell's Brook. Map shows Campbell's Brook from 1,000 m to 1,250 m.

Sutherland's Brook

Site Description

The surveyed section of Sutherland's Brook (Figure 8) is low gradient with small substrate size, and high degree of meander. Mean gradient at Sutherland's Brook over the 500 m surveyed was 0.46% (SD=0.29%, range 0.08-0.86%; N=10) (Figure 9). This is a very low gradient section, consistently less than 1.0% grade. The change in elevation over these 500 m is only 2.3 m. Visual estimates of substrate in Sutherland's Brook indicate it is primarily of small material, and this is consistent with the low gradient. Mean estimates of percentages of fines and small gravels together account for 73% of the substrate, with cobble representing <5% of substrate (Table 2). Much of the substrate is composed of organic material and silts. This fine size substrate precludes use of the Wolmann pebble count as the large proportion of the substrate would not be included in that method. Mean depth across 11 measured transects was 17.4 cm (SD=19.4). Cross section transects are presented in Appendix 1.

There is an abundance of fish cover in the form of undercut banks (when flow is approaching bankfull) and large woody debris. Small woody debris (SWD) and large woody debris (LWD) were counted independently by two observers for independent estimates in 7 (SWD) and 9 (LWD) of the sections. Comparison of estimates by observers indicates inter-observer variability is low. For SWD the mean difference between the observers was 1.28 pieces/50 m (SD=6.99; N=7) while for LWD was 0.22 pieces/50m (SD=4.11; N=9). This provides confidence that the number of pieces of woody debris, particularly the LWD, are accurately counted. Based on these counts the mean number of SWD in this 500 m surveyed section of Sutherland's Brook per 50 m is 13.2 pieces/50 m (SD=5.79) and for LWD is 13.3 pieces/50 m (SD=7.60).

The channel morphology is good with a sinuosity index of 1.81 indicating a meandering channel (Mount, 1995) and channel width is quite consistent throughout the section (Table 2). The abundant LWD works to maintain channel morphology and the banks are stable. The channel width appears to be appropriate for the drainage area (i.e., not overwidened). The riparian condition is good to excellent with young to mature mixedwood forest. Finally, the stream has been identified as a cool water system in the St. Mary's River by the St Mary's River Association (unpublished data) and of "Intermediate"[5] temperature regime by MacMillan et al. (2005).

[5] MacMillan et al. (2005) define cool water as mean summer temperature <16.5°C, warm water systems as mean summer temperature >18.9°C, and intermediate between the two temperatures.

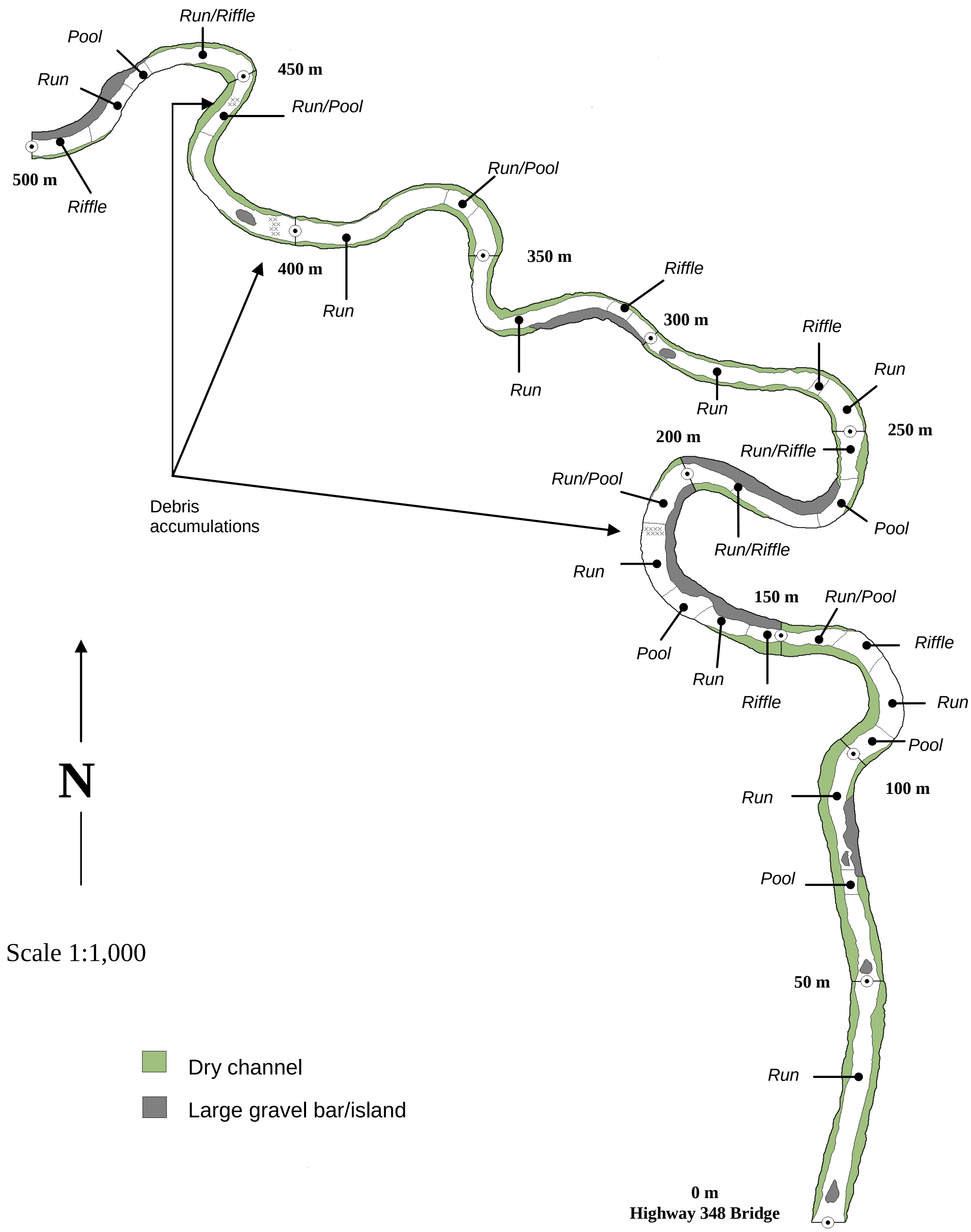


Figure 8: Map of Sutherland's Brook based on field survey, September, 2011 showing habitat distribution and key channel features. Map shows Sutherland's Brook from Highway 348 bridge (0 m) upstream for a distance of 500 m.

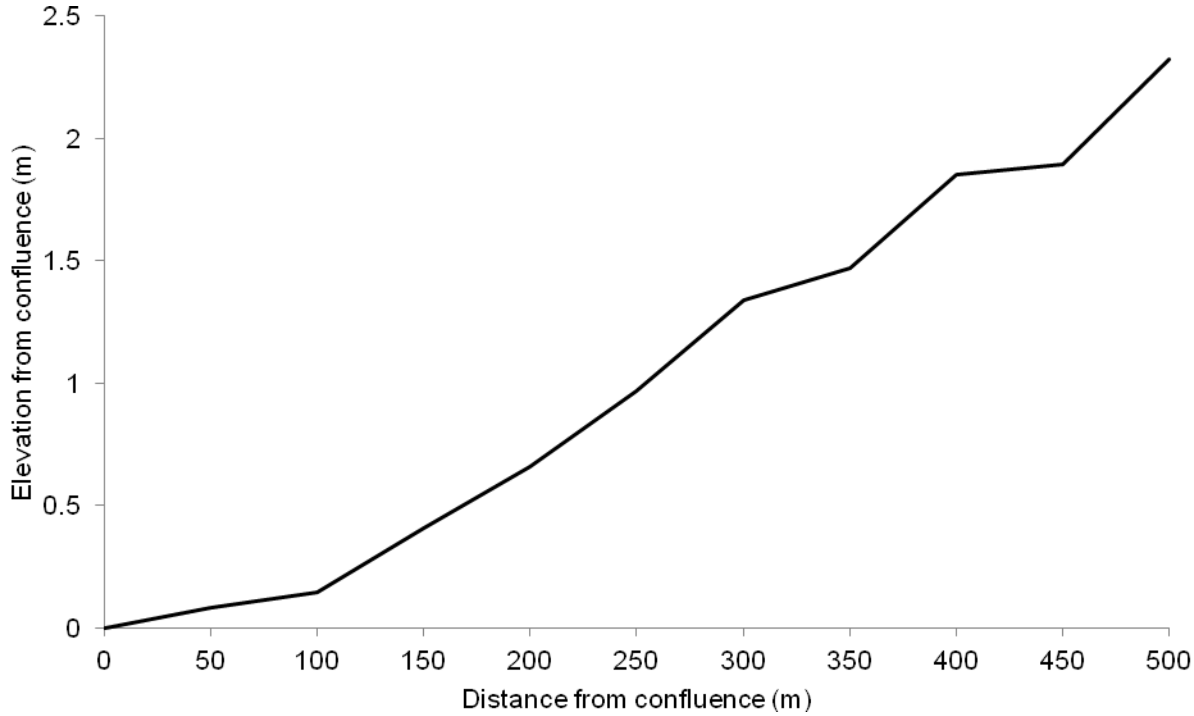


Figure 9: Longitudinal profile for 500 m of Sutherland's Brook upstream of Highway 348 bridge surveyed in 2011.

Limiting Factors (Sutherland's Brook)

The limiting factors to fish production in this stream are:

- Loss of water in channel during low flow periods in Sections 2 and 3 (50-150 m). Causes of this loss are unknown. The fine substrate is expected to reduce percolation, but during low water periods this section does almost entirely dewater, leaving only very shallow, isolated channels.
- Low frequency of pools and domination by runs (Table 2). In gravel bed river sections (which this is not), riffle-pool ratios should approximate 75%:25% for salmon and 50%:50% for trout (Thaumas Environmental Consultants, 2005). However, ratios for non-gravel bed sections are not established. Nonetheless, run dominance and pool absence likely limit production in this section.
- The low gradient and fine substrate of this section limit salmonid production as Atlantic salmon and brook trout both prefer higher gradient habitats with riffle-pool sequences. This section of Sutherland's Brook may be viewed as significant to non-salmonid species and forming a likely access constraint to upstream sections by salmonids during low flow conditions.

Purpose of restoration

The purpose of restoration in Sutherland's Brook is to ensure fish passage during low flow conditions from the Highway bridge upstream for 250 m (i.e., Sections 1-5). Restoring this section for salmonid production is not feasible as the geomorphic and channel dynamics are simply not appropriate here for these species.

Sutherland's Brook Restoration Plan

To restore passage through the 250 m section upstream of the highway bridge during low flow conditions, placement of paired deflectors is recommended. These deflectors will locally reduce stream width and increase depth, thereby focussing the flow during low water conditions and allowing fish use/passage. Deflectors are to be installed approximately every six channel widths (Thaumas Environmental Consultants, 2005) which is approximately every 36 m on Sutherland's Brook. This will amount to six paired deflectors over the 250 m upstream of the highway bridge (Figure 10). A limitation of these deflectors in Sutherland's Brook is a lack of available rock (cobble and boulder) with which to backfill the deflector and so provide support. The deflectors will be filled with available material (gravel, available larger material, brush) in order to reduce scour when the deflector is over-topped during high water. The material excavated to fill the deflectors will come from the thalweg area of the stream in an effort to locally deepen the thalweg. The walls will also have to be well anchored into the soft bottom and securely keyed into the banks. The low gradient of the stream and lack of obvious ice-damage implying ice risk is not severe, will also reduce the need for large material to support the deflectors. Work on Sutherland's Brook may be done with hand tools and power saw. Wood is locally available (require permission from landowner prior to cutting any).

Budget for Sutherland's Brook Restoration

Below is a preliminary budget. Costs are rough estimates, not based on quotes. A more refined budget will be required prior to seeking funding.

Total estimated cost for proposed restoration: **$9,670**, broken down as:

Cost Component	Rate	Total Cost
Manpower		
Technical expertise/advice (NSLC Adopt-a-stream)	1 days at $300/day	$300
Project management (SMRA) (layout of site, monitoring of activity; reporting and documenting	5 days @ $300/day	$1,500
Laborers (crew of 3 for 20 days)	$105/day/man for 20 days+ MERC	$7,000
Crew travel	1000 km (50 km/d * 20 days) @ $0.37/km	$370
Equipment & Materials (Rebar, cable, wheelbarrow)	$500	$500
Total		**$9,670**

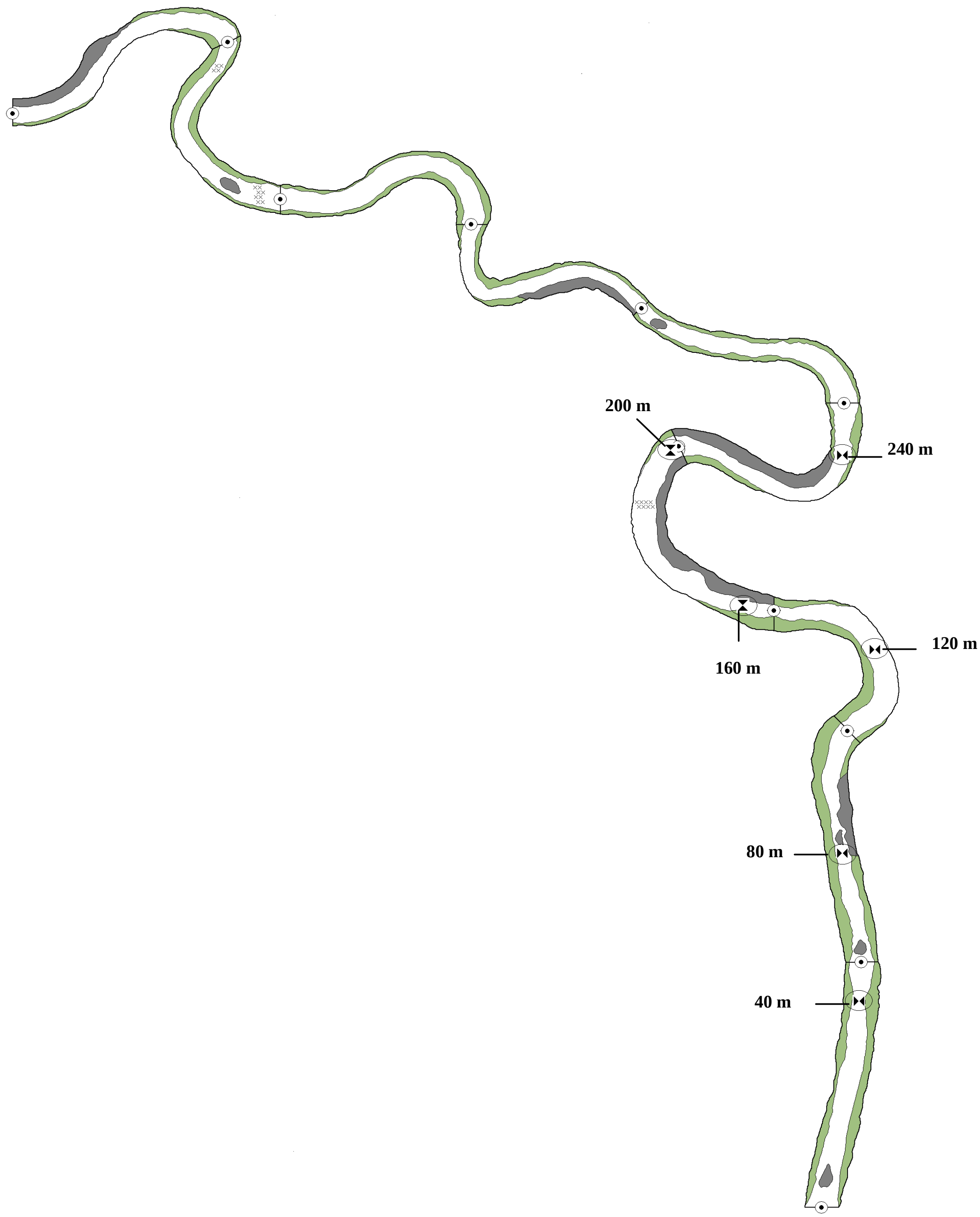


Figure 10: Conceptual diagram of restoration (six paired deflectors) in Sutherland's Brook.

5.0 CONCLUSION

These two brooks, the highest priority for restoration yet encountered in the St. Mary's River are fundamentally different brooks, requiring different restoration approaches. Campbell's Brook is highly impacted by land use practices, a highly manipulated channel, and poses a likely movement barrier as well as being of low habitat value over a long distance. Restoration will be intensive and expensive due to the requirement of rockwork and machine time. In contrast, Sutherland's Brook is not impacted by land use practices and appears to be in largely good condition, apart from isolated areas of dewatering during low flows which likely impede movement through the channel. The problem area is short and the restoration actions easily undertaken with labour and hand tools. These two streams could have the required restoration activities take place on them in the same summer season.

6.0 RECOMMENDATION

There is only a single recommendation coming out of this work, in addition to the proposed restoration activities. This applies to Campbell's Brook.

(#1) Temperature recordings using data loggers should be conducted on Campbell's Brook through summer 2012 with deployment of loggers upstream of the agricultural fields (i.e., 1,200 m upstream) and downstream of fields (i.e., within lower 200 m of brook) between June and October. This is required to assess the degree of heating shown by Campbell's Brook as it flows through agricultural fields and thus the need for restoration for temperature regulation.

7.0 LITERATURE CITED

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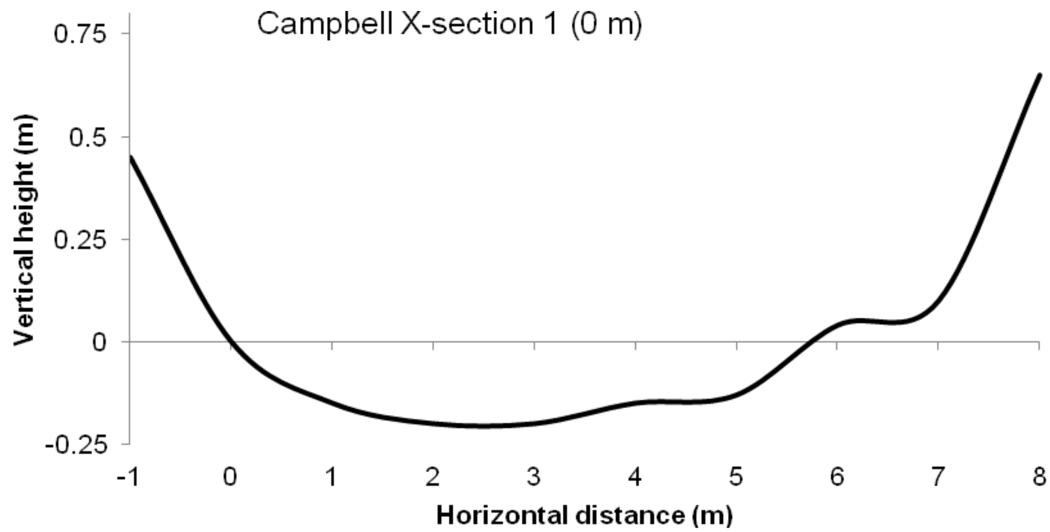
APPENDIX 1: CROSS SECTIONS OF TRANSECTS FOR CAMPBELL'S BROOK AND SUTHERLAND'S BROOK.

Cross sections are presented as though looking downstream with left bank on left and right bank on right.

All measurements made from water's edge on left bank (0, 0) with depths presented as negative values and elevations above water (banks) as positive. Negative values (horizontal) of left bank represent distance from water's edge.

CAMPBELL'S BROOK CROSS SECTIONS.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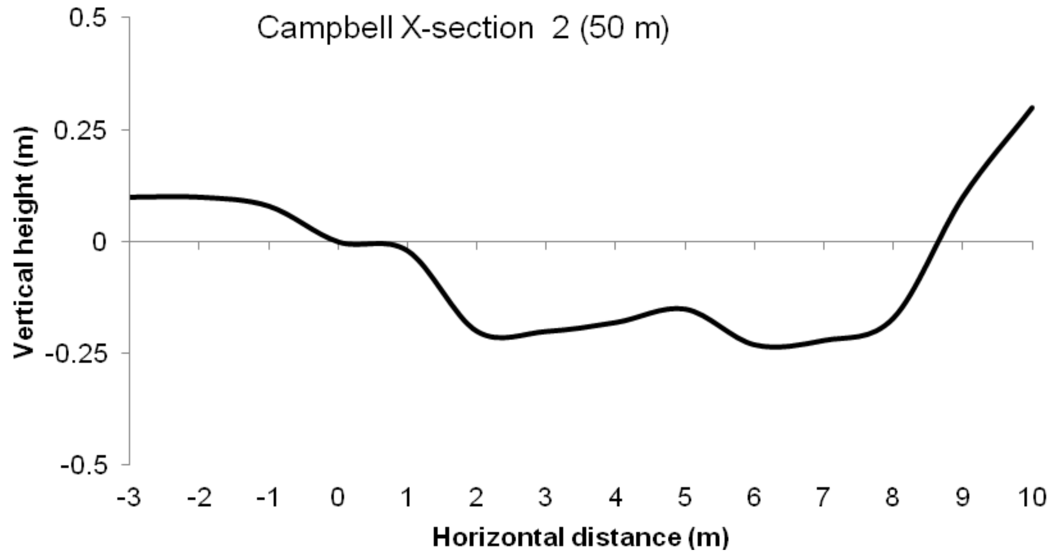
2
3
4
5
6
7
8
Horizontal distance (m)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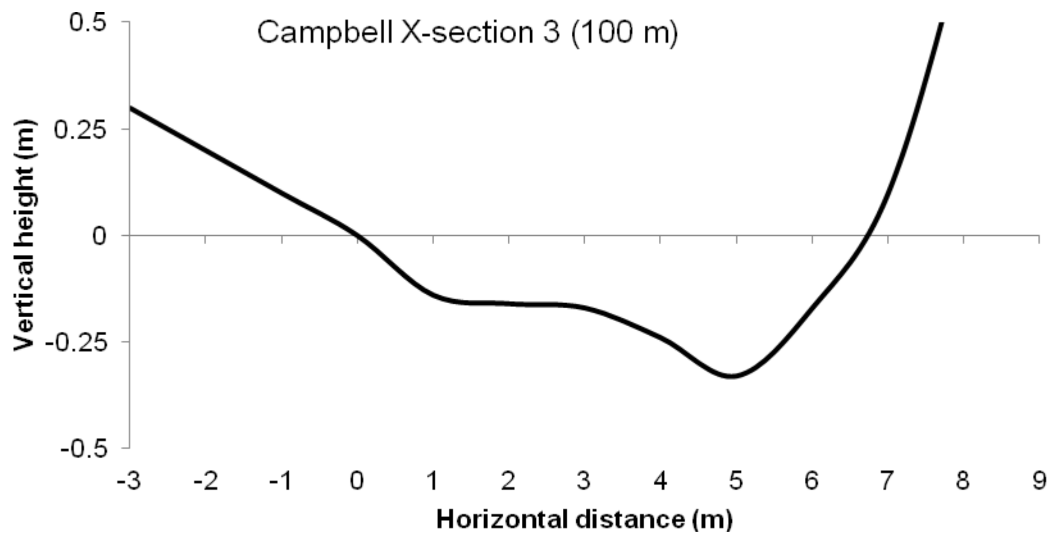
5
6
7
8
9
10
Horizontal distance (m)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Vertical height (m)
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0.25
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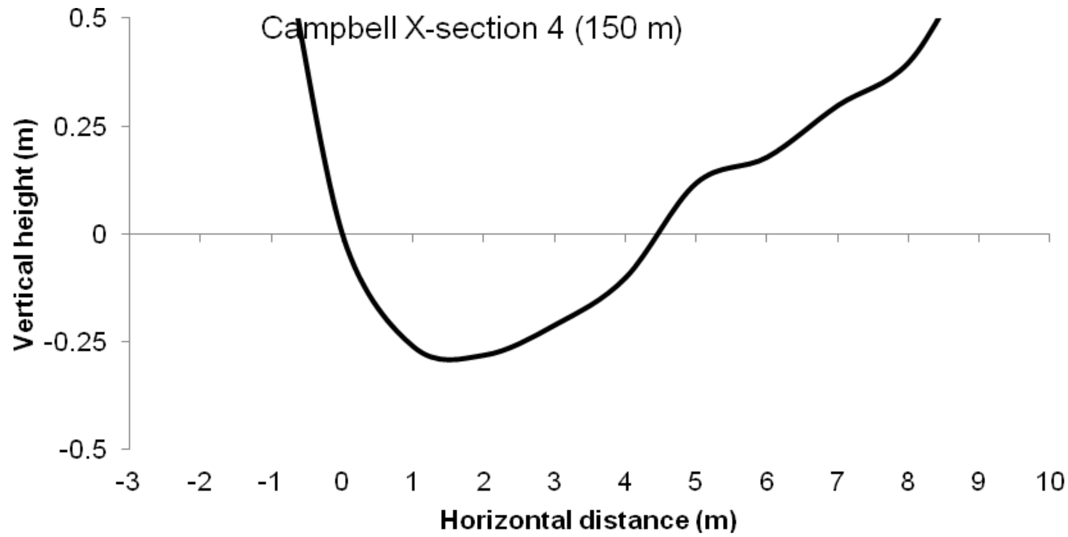
4
5
6
7
8
9
Horizontal distance (m)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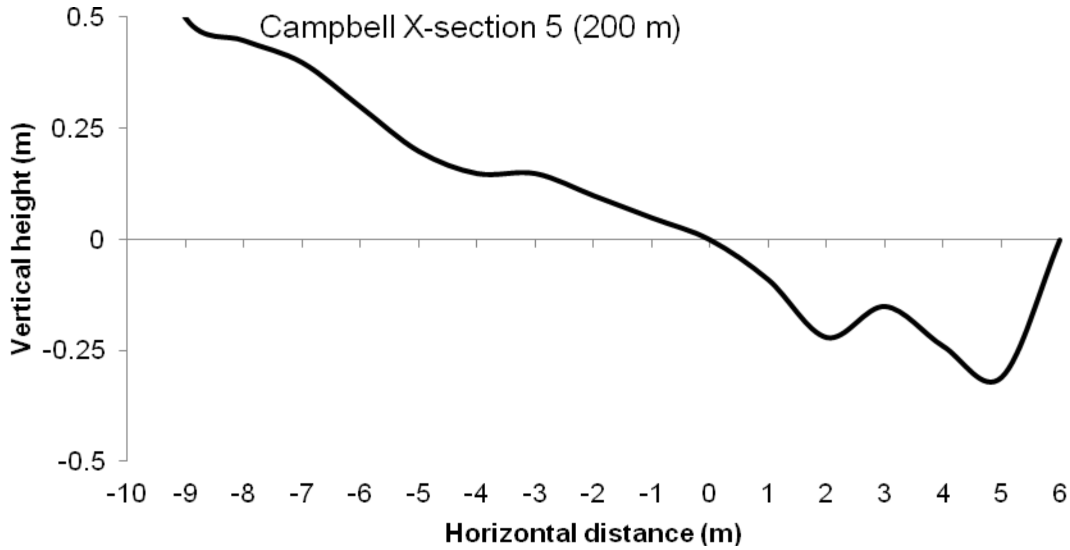
Horizontal distance (m)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Vertical height (m)
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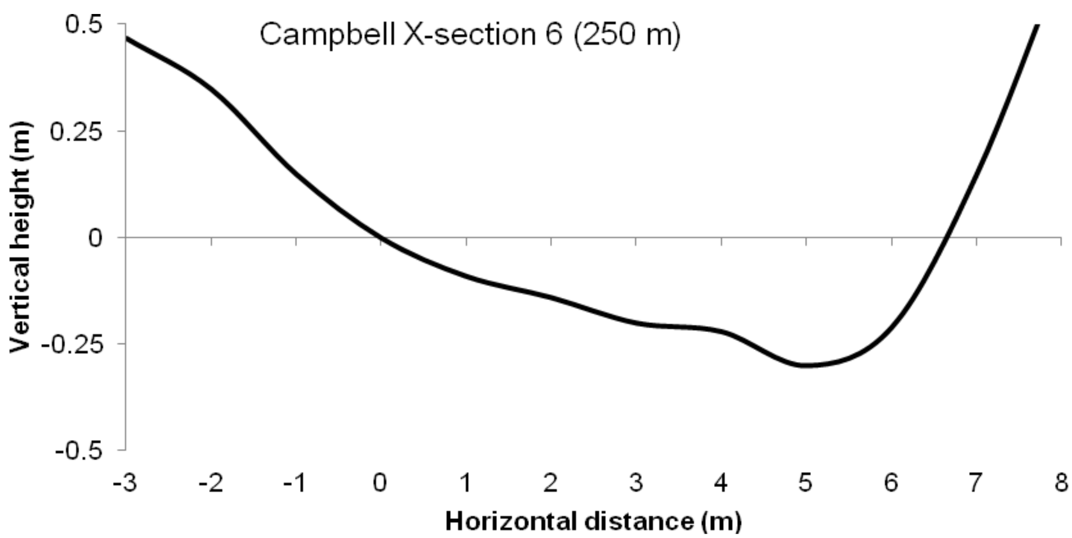
Horizontal distance (m)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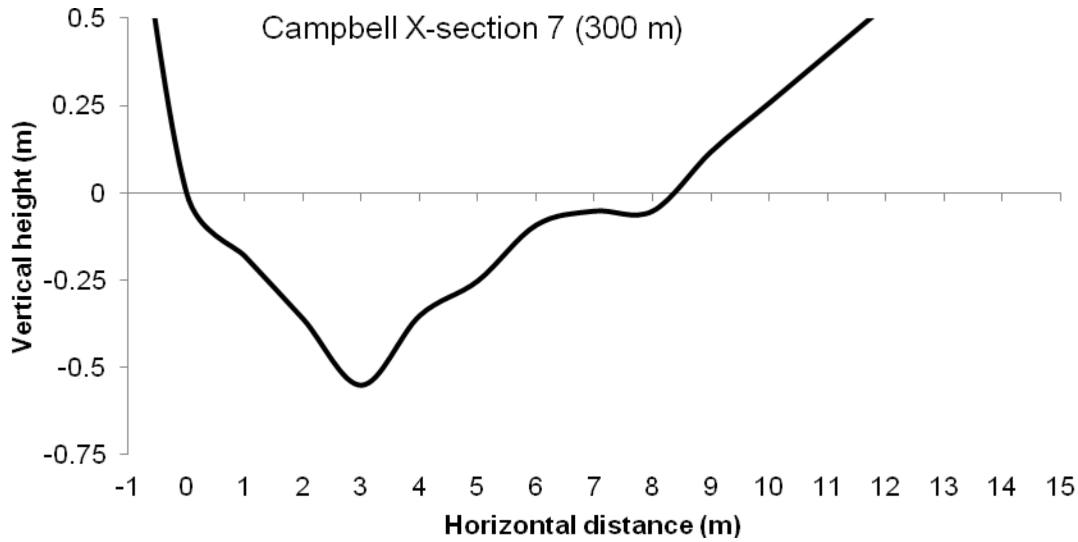
-0.5
-3 -2 -1 0 1 2 3 4 5 6 7 8
Horizontal distance (m)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Vertical height (m)
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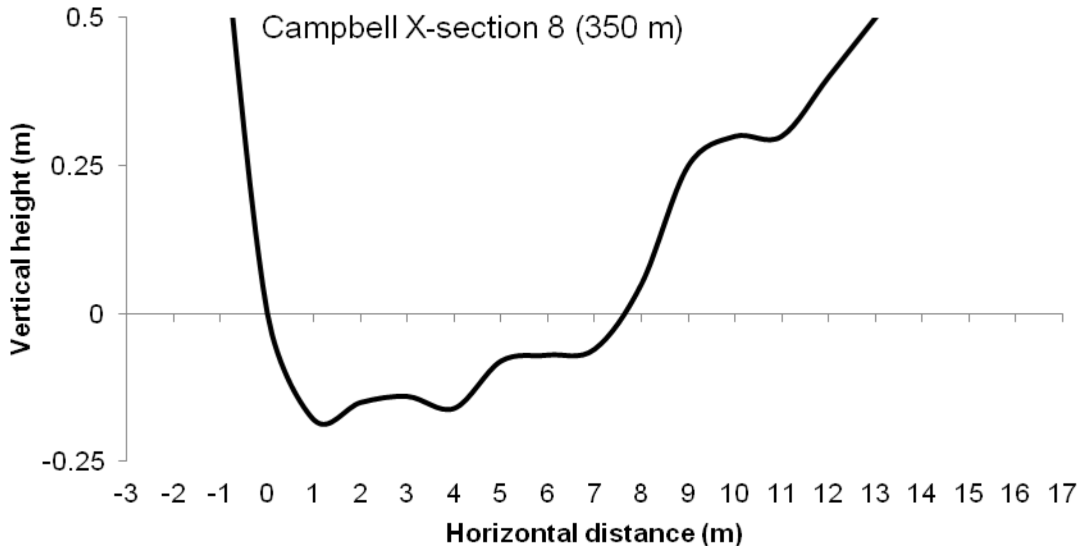
Horizontal distance (m)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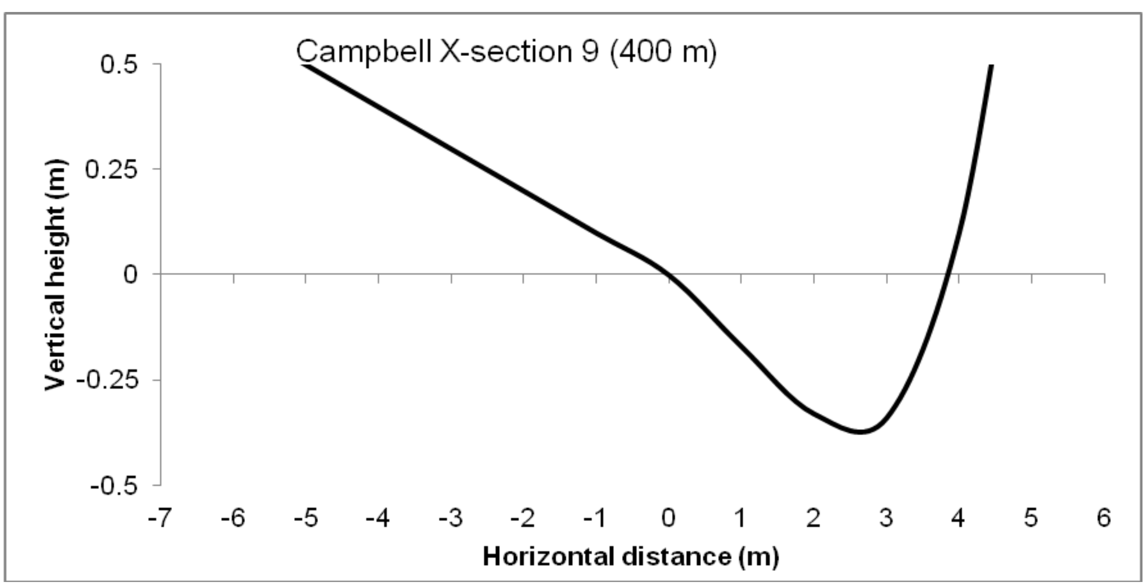
Horizontal distance (m)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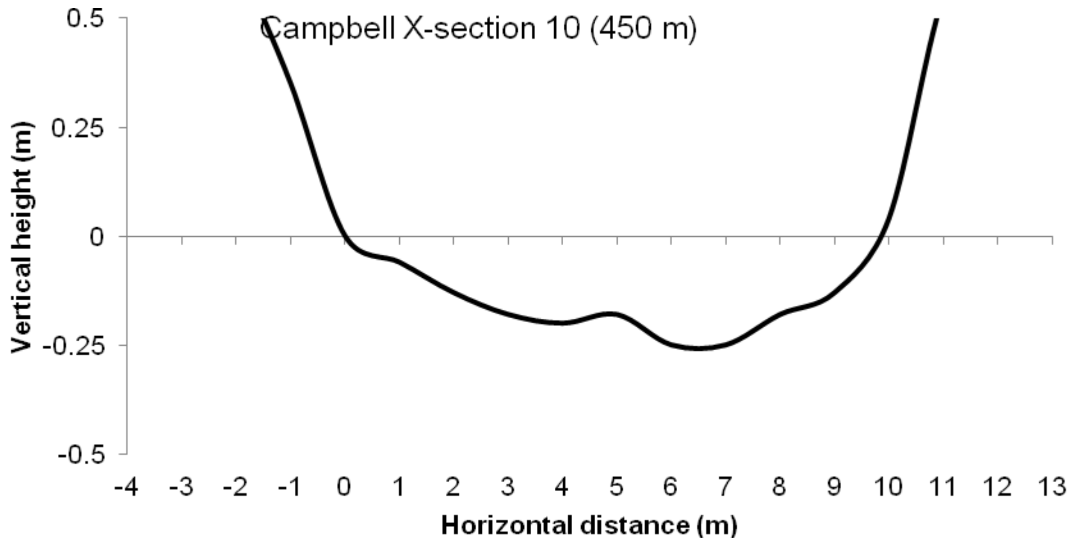
Horizontal distance (m)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Vertical height (m)
Horizontal distance (m)
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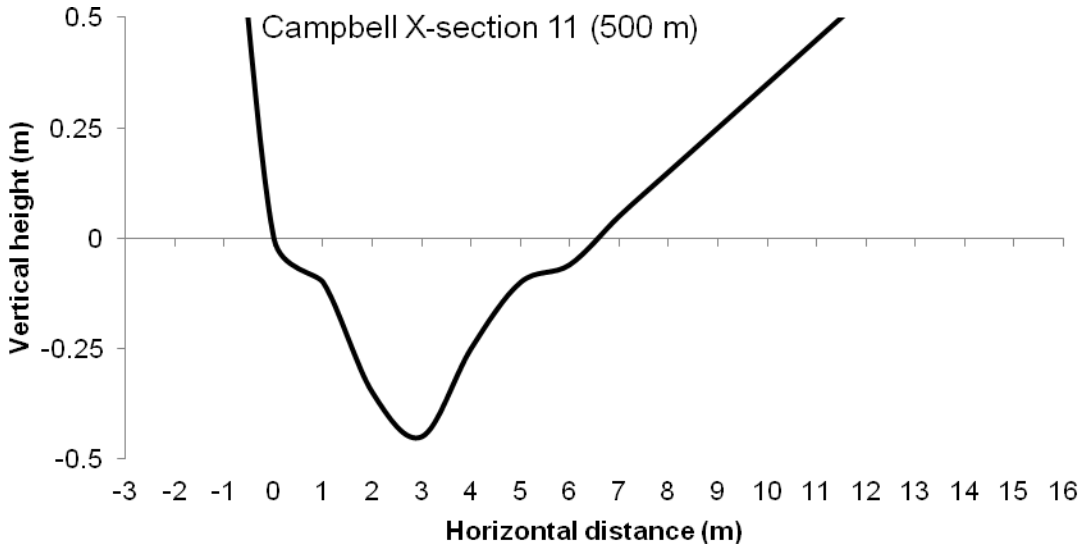
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Vertical height (m)
Horizontal distance (m)
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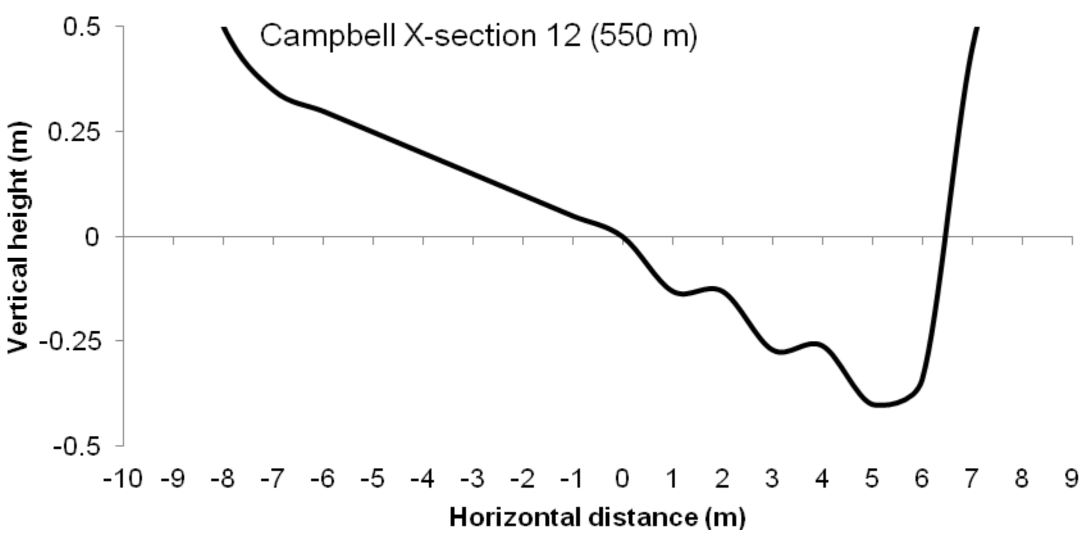
Campbell X-section 12 (550 m)
Vertical height (m)
Horizontal distance (m)
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-0.5
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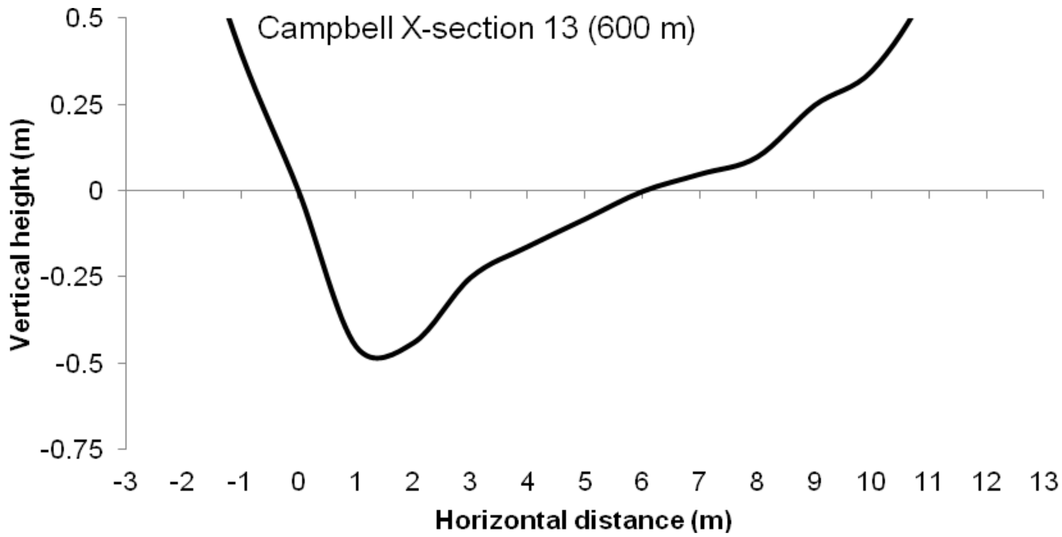
Campbell X-section 13 (600 m)
Vertical height (m)
Horizontal distance (m)
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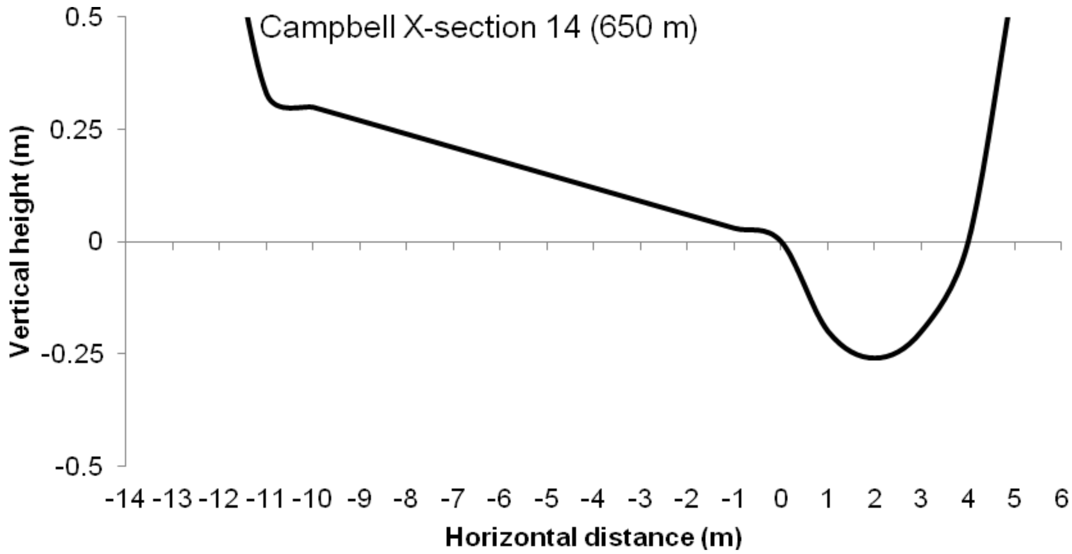
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Vertical height (m)
Horizontal distance (m)
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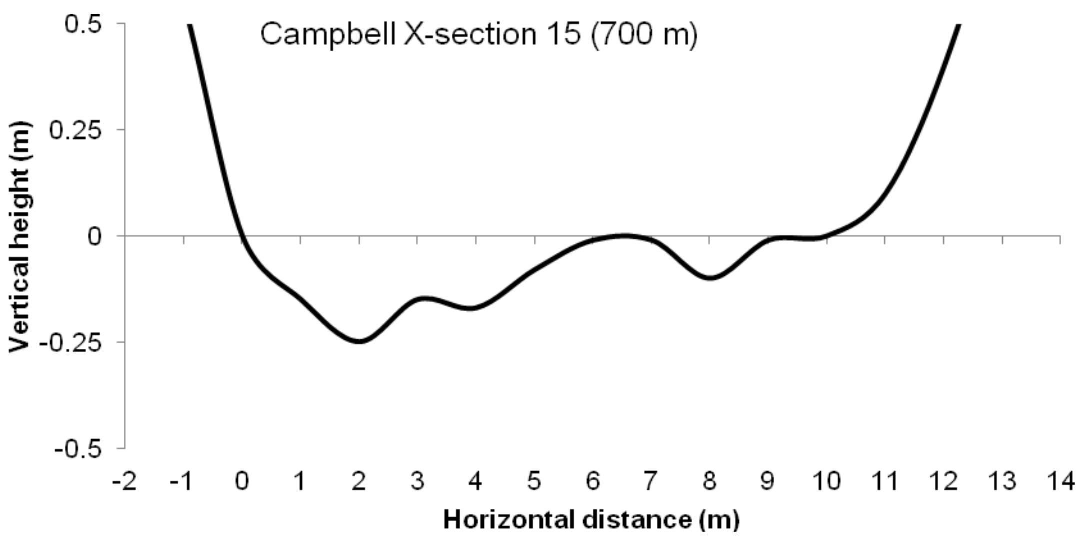
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Vertical height (m)
Horizontal distance (m)
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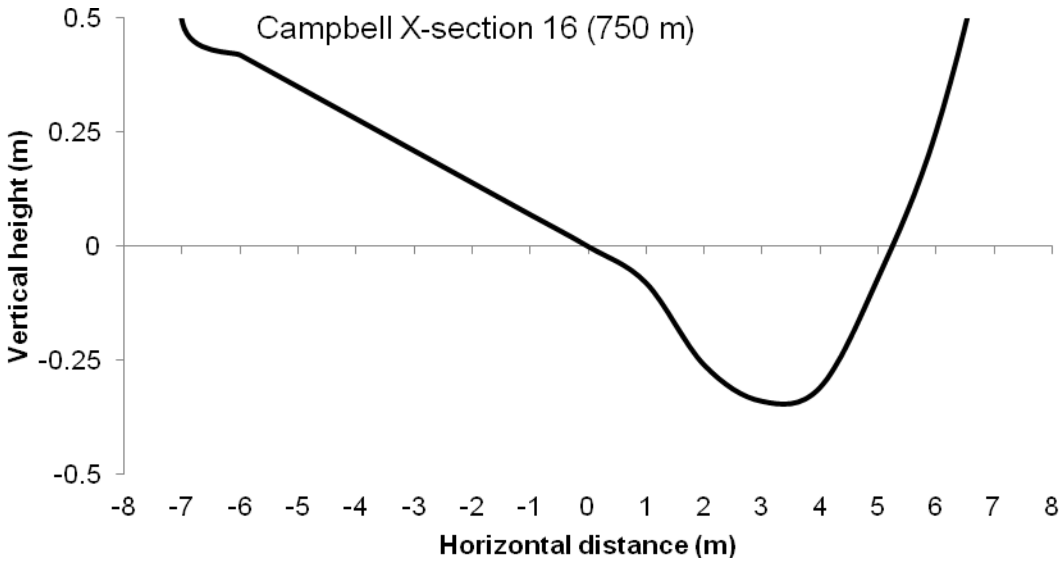
Campbell X-section 16 (750 m)
Vertical height (m)
Horizontal distance (m)
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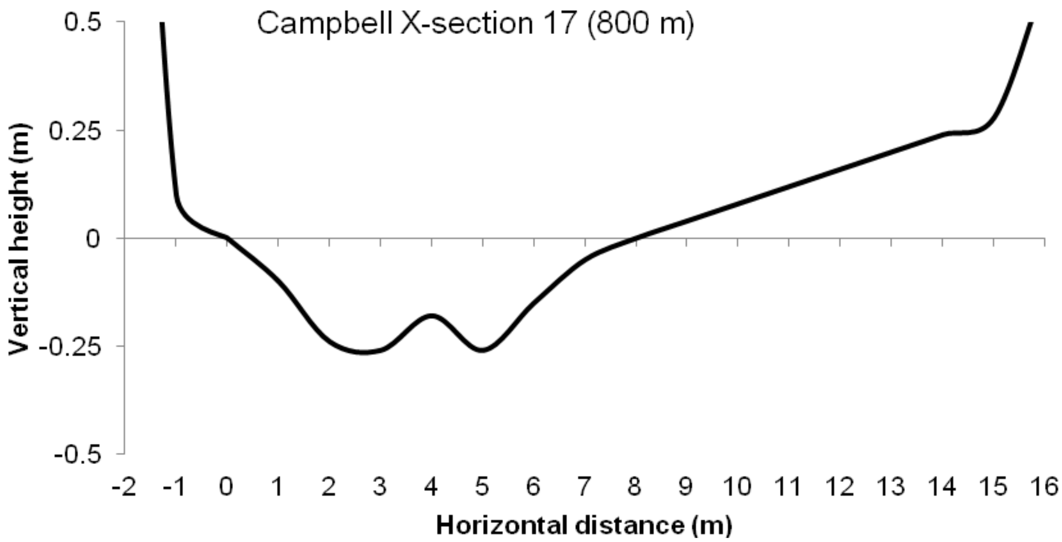
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Vertical height (m)
Horizontal distance (m)
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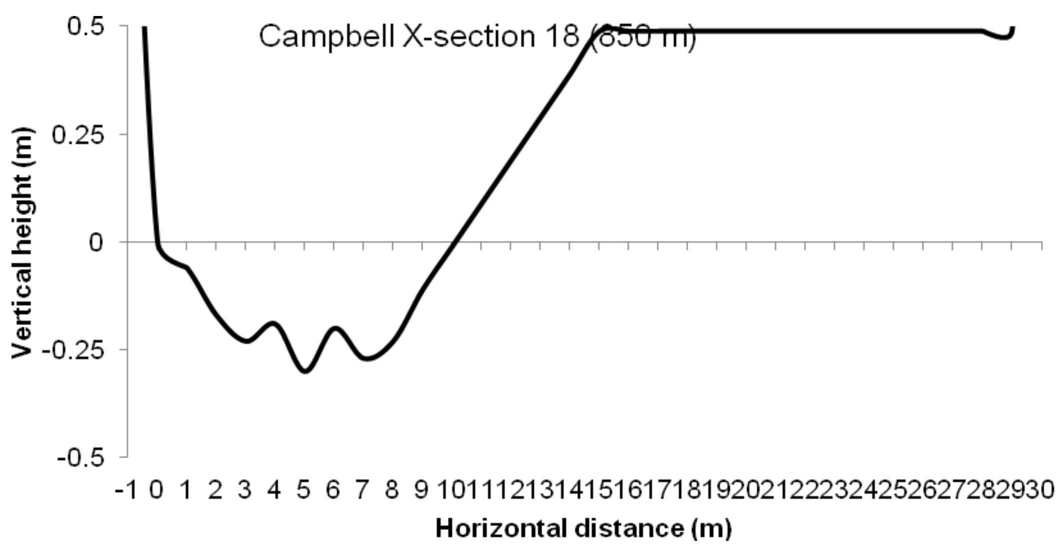
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Vertical height (m)
Horizontal distance (m)
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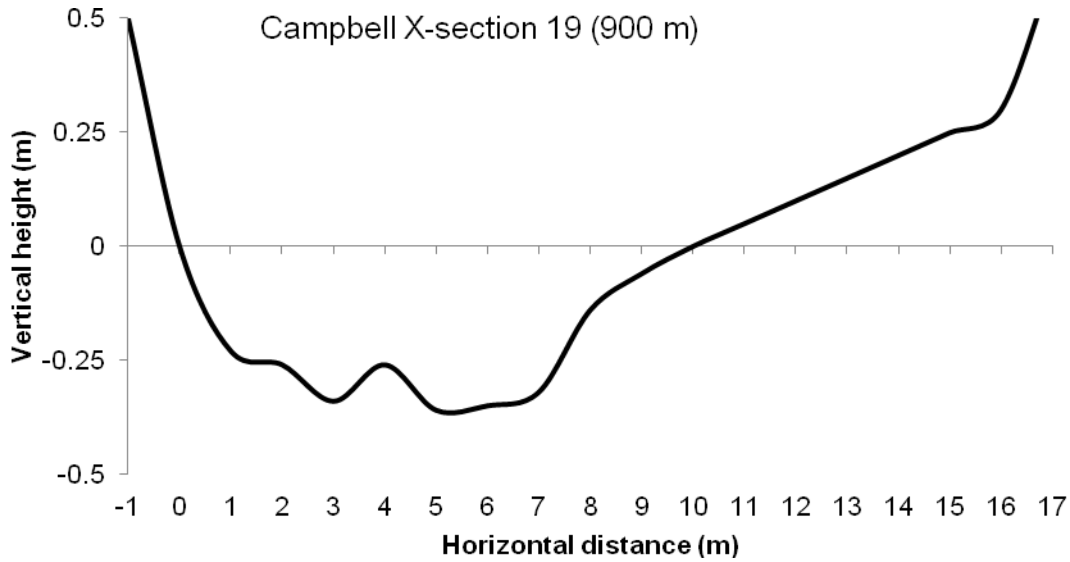
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Vertical height (m)
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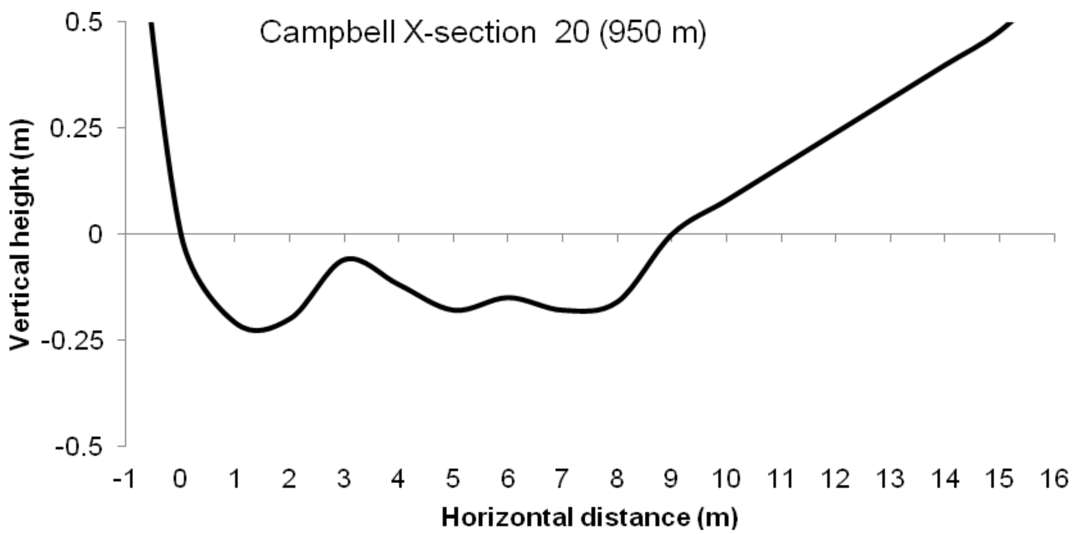
Horizontal distance (m)


Campbell X-section 20 (950 m)
Vertical height (m)
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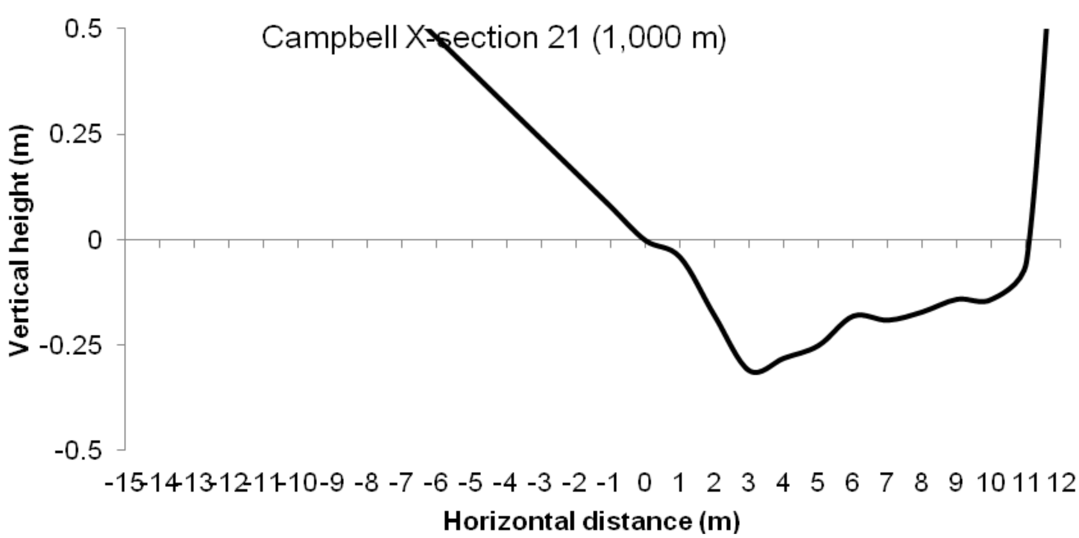
Horizontal distance (m)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Vertical height (m)
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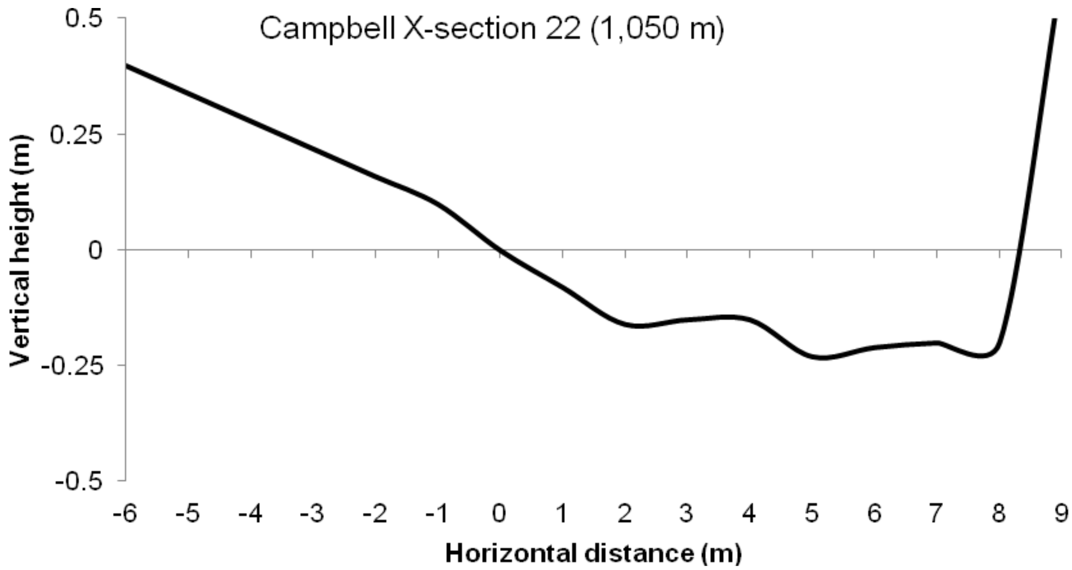
Horizontal distance (m)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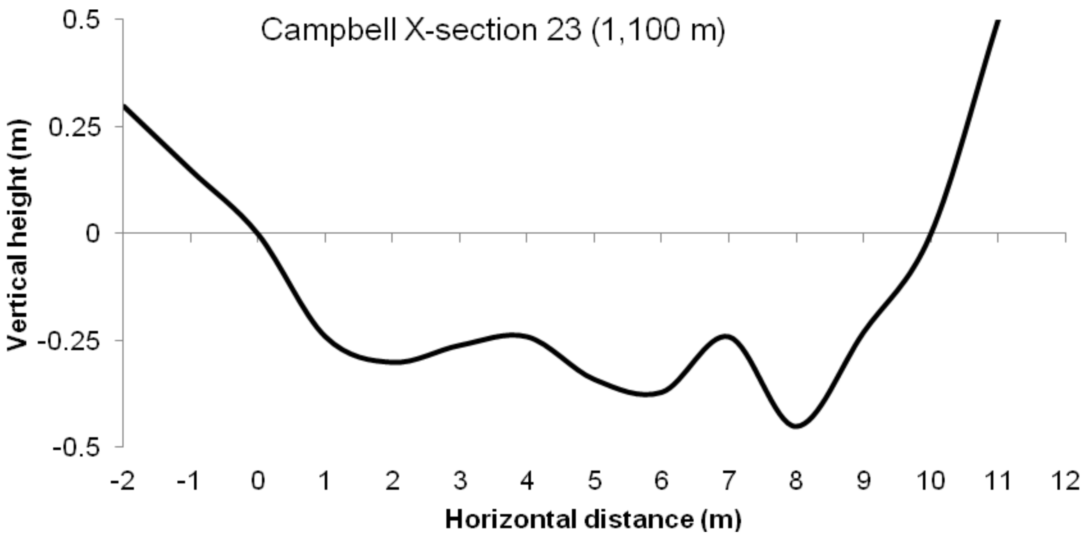
Horizontal distance (m)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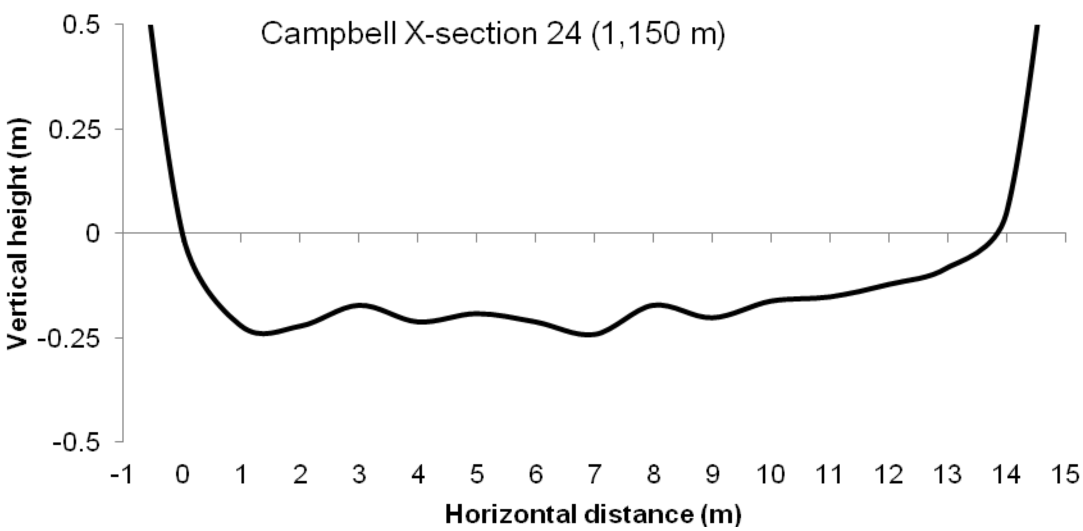
Horizontal distance (m)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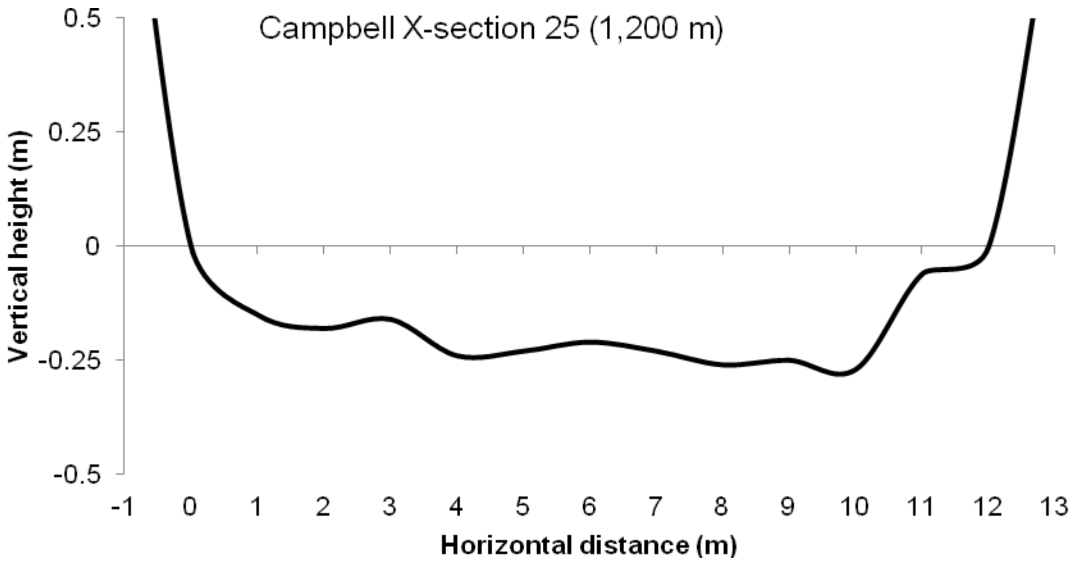
Horizontal distance (m)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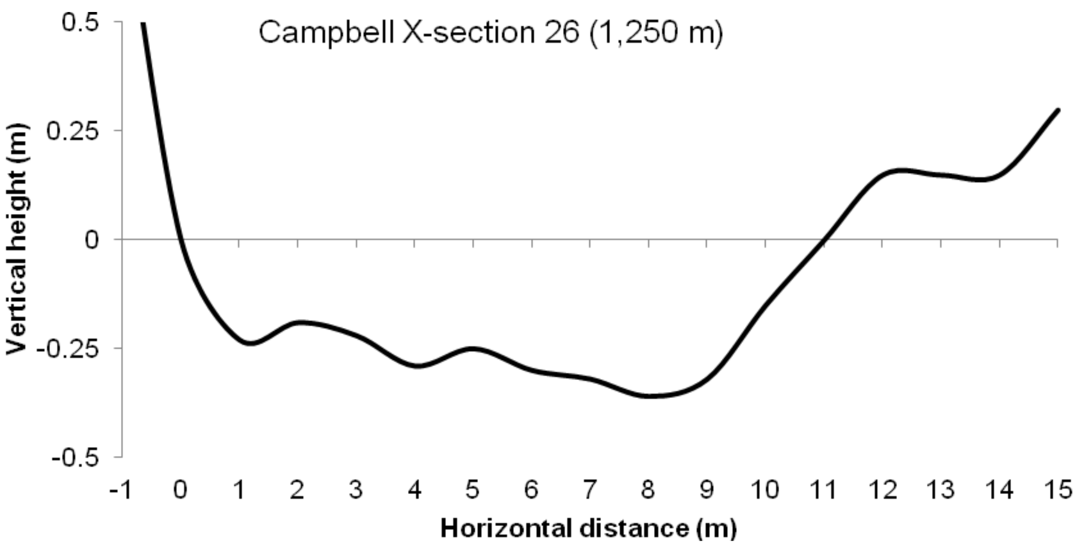
Horizontal distance (m)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Vertical height (m)
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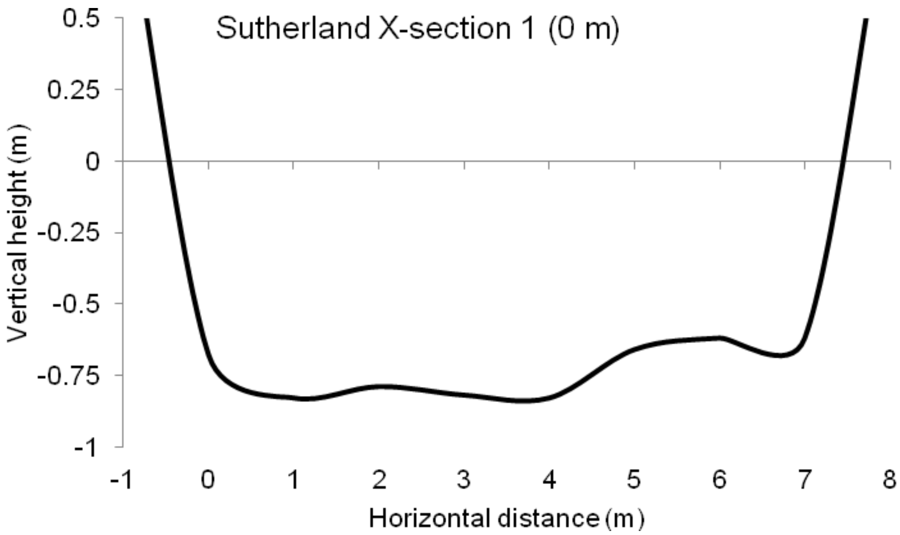
Horizontal distance (m)

SUTHERLAND'S BROOK CROSS SECTIONS.


Sutherland X-section 1 (0 m)
Vertical height (m)
Horizontal distance (m)
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5
6
7
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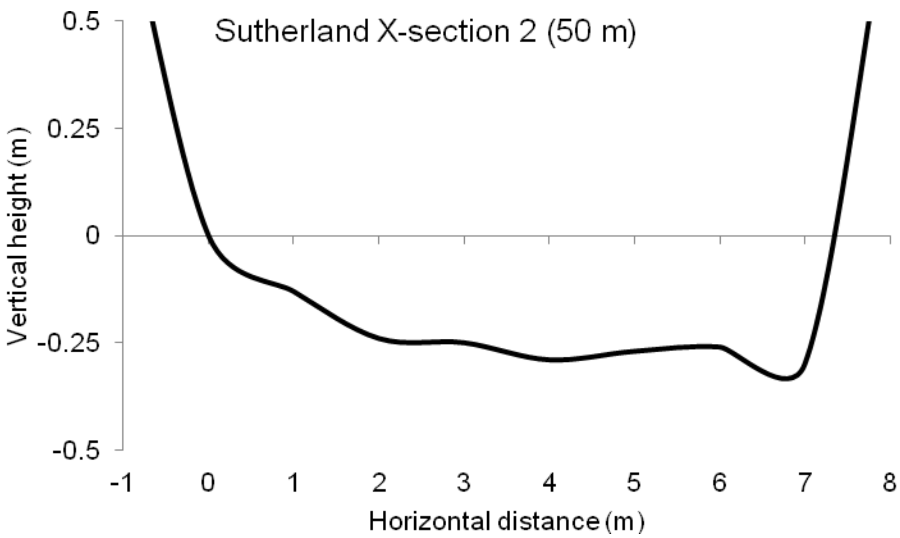
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Vertical height (m)
Horizontal distance (m)
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6
7
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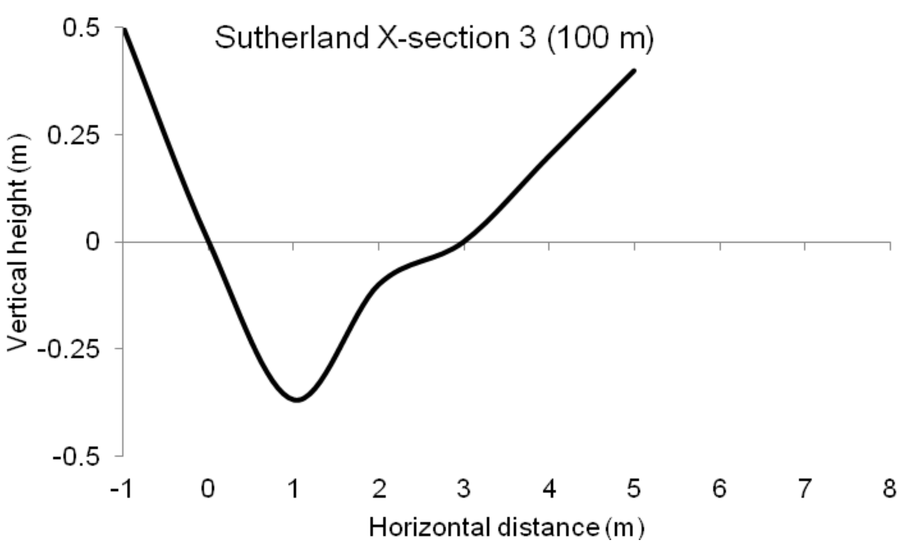
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Vertical height (m)
Horizontal distance (m)
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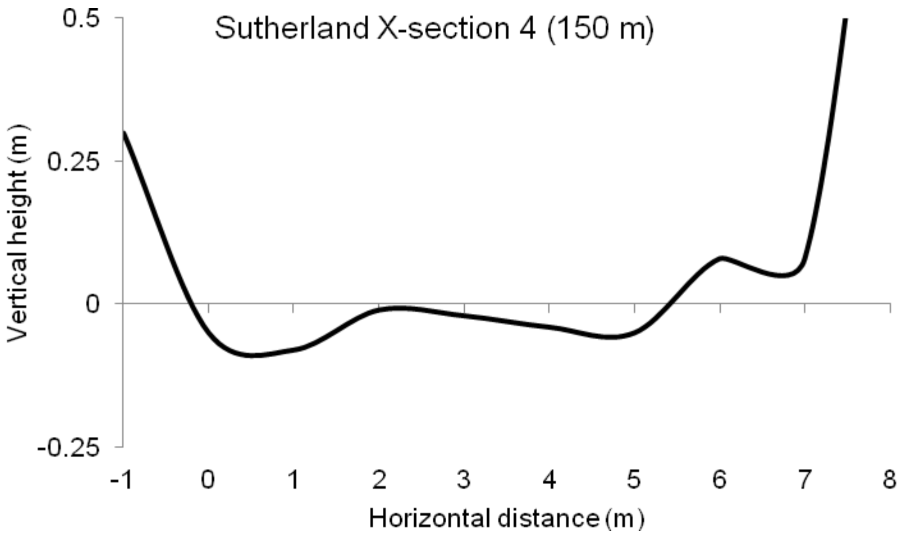

Sutherland X-section 4 (150 m)
Vertical height (m)
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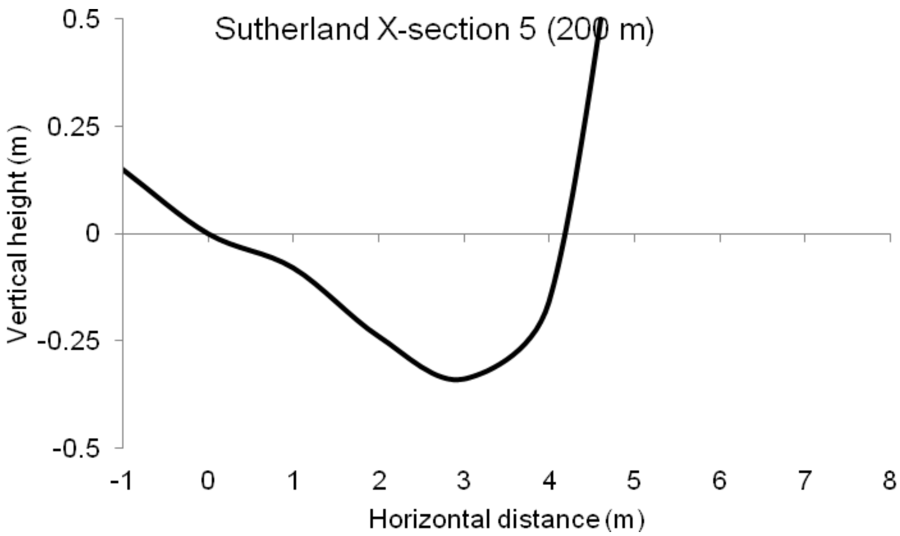
-0.25
-1
0
1
2
3
4
5
6
7
8
Horizontal distance (m)



Sutherland X-section 5 (200 m)
Vertical height (m)
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0.25
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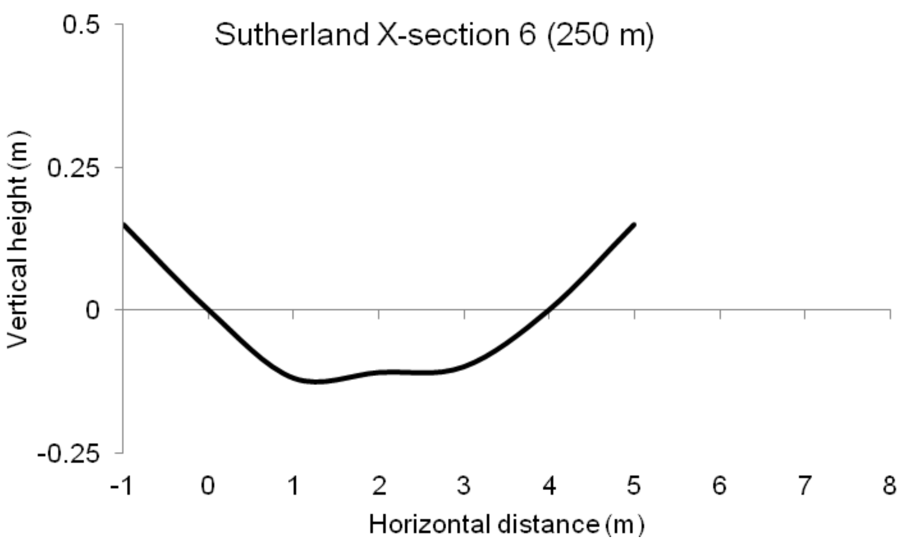
-1
0
1
2
3
4
5
6
7
8
Horizontal distance (m)



Sutherland X-section 6 (250 m)
Vertical height (m)
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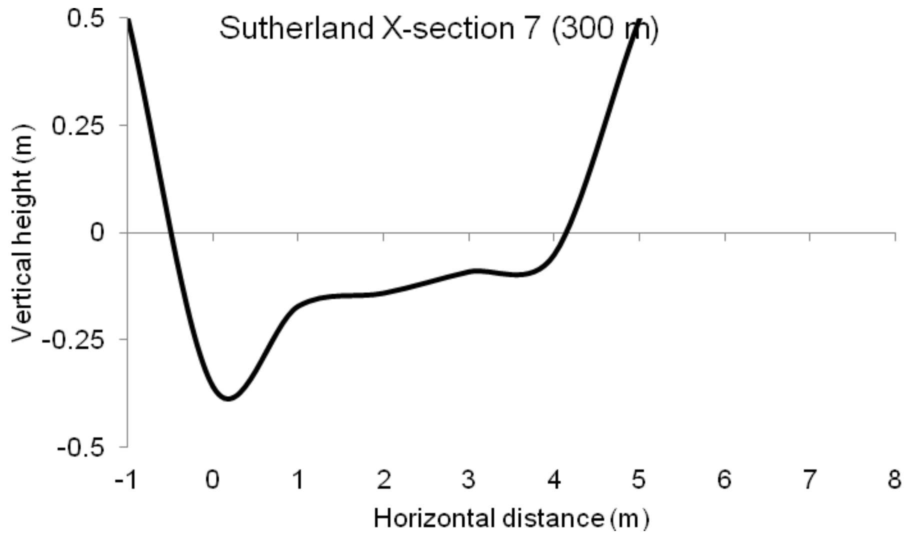
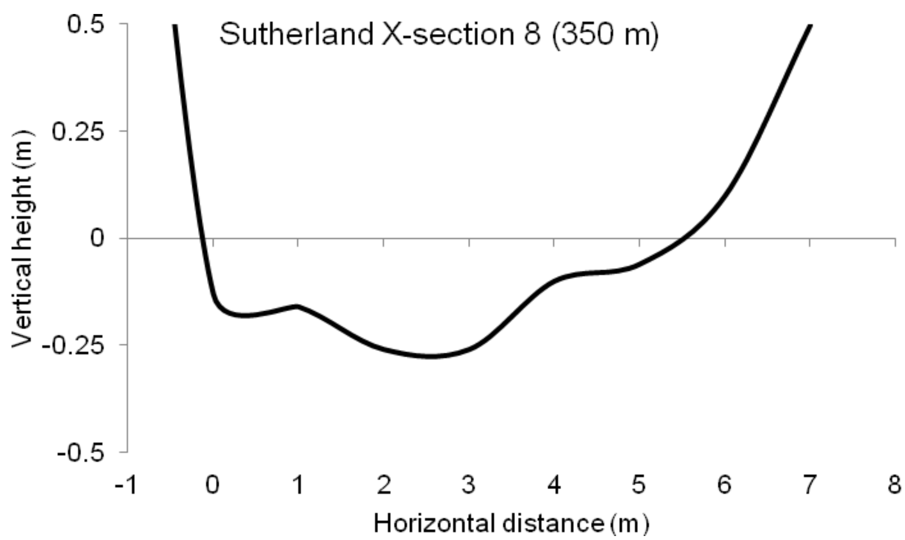
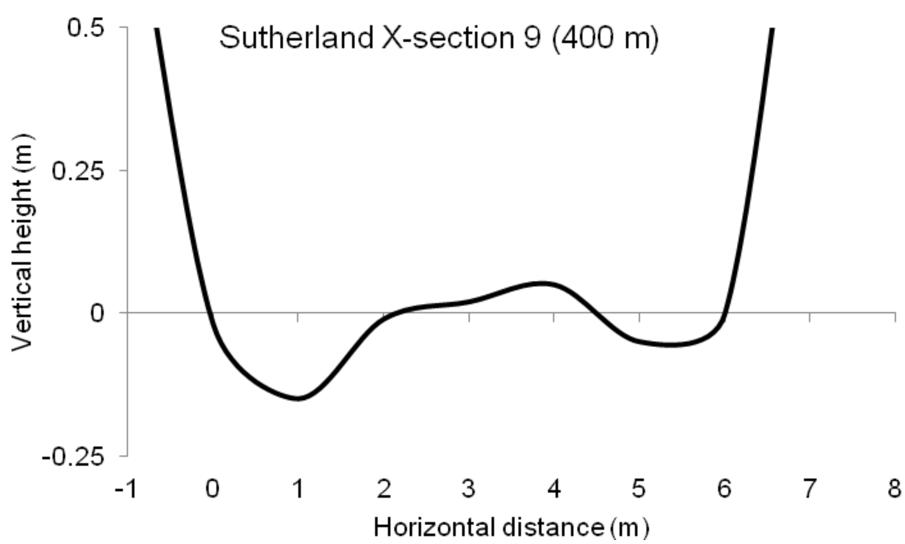
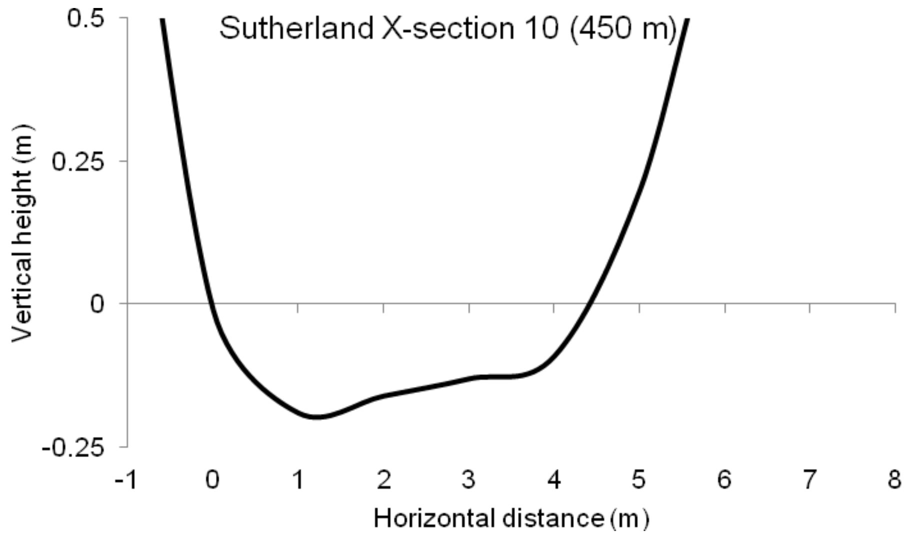
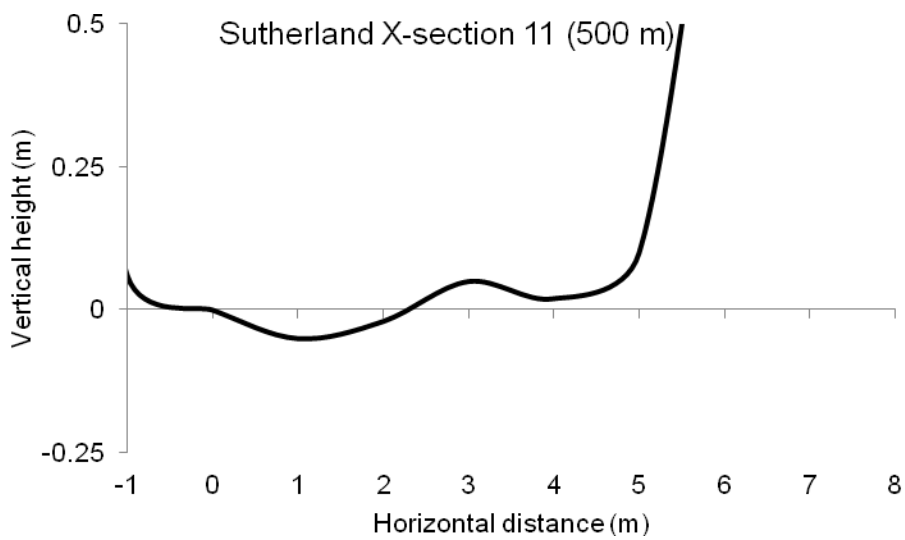
2
3
4
5
6
7
8
Horizontal distance (m)


Sutherland X-section 7 (300 m)
Vertical height (m)
0.5
0.25
0
-0.25
-0.5
-1
0
1
2
3
4
5
6
7
8
Horizontal distance (m)


Sutherland X-section 8 (350 m)
Vertical height (m)
0.5
0.25
0
-0.25
-0.5
-1
0
1
2
3
4
5
6
7
8
Horizontal distance (m)


Sutherland X-section 9 (400 m)
Vertical height (m)
0.5
0.25
0
-0.25
-1
0
1
2
3
4
5
6
7
8
Horizontal distance (m)


Sutherland X-section 10 (450 m)
Vertical height (m)
0.5
0.25
0
-0.25
-1
0
1
2
3
4
5
6
7
8
Horizontal distance (m)


Sutherland X-section 11 (500 m)
Vertical height (m)
0.5
0.25
0
-0.25
-1
0
1
2
3
4
5
6
7
8
Horizontal distance (m)