ELK RIVER
2005 CHANNEL STABILIZATION PROJECT
AND YEAR 2 MONITORING REPORT

December 12, 2005

Streamline
ENVIRONMENTAL CONSULTING LTD

ELK RIVER 2005 CHANNEL STABILIZATION PROJECT AND YEAR 2 MONITORING REPORT

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Project # 05CA02

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EXECUTIVE SUMMARY

The Elk River is a tributary to Upper Campbell Lake, which is impounded by the Strathcona Dam operated by BC Hydro. Over the past 70 years the river has changed from a comparatively narrow, single thread, stable channel to a multi-thread, laterally unstable, aggraded channel. This change has resulted in a four to seven times increase in the un-vegetated channel width. The change is likely the result of several factors including valley bottom logging, channel confinement and relocation due to road construction, a landslide in the river's headwaters, and the increase in flows from the diversion of water into the Elk River from the adjacent Heber River drainage.

Previous channel morphology studies demonstrated the need for river restoration efforts in the Elk River to focus on restoring channel processes. In 2004, work began at the Elk River to stabilize several gravel bars and speed the natural recovery through the soil bioengineering process of live staking. Live staking involves planting deciduous tree segments, or 'stakes' into the gravel bars at high densities. The live staking will, over time, be expected to cause sediment deposition and gravel storage in the treated areas. This will promote the establishment of riparian vegetation and further accumulation of flood borne materials in treated areas, elevating and stabilizing the gravel bars and forcing the river to scour a narrower and deeper mainstem channel.

In 2004 three sites totaling 1.86 ha were planted with approximately 17,200 stakes ha^{-1}. At that time baseline monitoring was done to establish site conditions, including vegetation, gravel bar topography and substrate composition. Monitoring in 2005 indicated that the live stakes have an overall survival rate of 90 %. There have been losses to elk and deer browsing on the stakes however that has been confined mostly to the red-osier dogwood and cottonwood stakes. With the exception of the live stake growth only small changes to the sites were noted. It is expected that, as the stakes continue to grow there will be a greater response in channel form and plant succession.

Live staking began with the collection of donor stock in late September. Stock collection consisted of cutting down and de-limbing deciduous trees. The trees were then bundled and soaked in water for several days to remove rooting inhibitors prior to planting. Silviculture crews from the Mowachaht-Muchalaht First Nation performed the work. The donor stock consisted mainly of willow trees however some red-osier dogwood and cottonwood and a few maple trees were also used.

In total 1.41 ha was planted with live stakes at an average density of 8600 stems ha^{-1}. Post-treatment surveys benchmarked the planted area and channel form. Permanent research plots were established and baseline data collected on the number of stakes planted, stake species, natural vegetation and substrate composition. Future monitoring of these performance indicators will allow for the determination of the success of the live staking in achieving the project goals. This information can then be used to help direct future restoration activities.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1.0 INTRODUCTION

The 2005 Elk River Channel Stabilization project is a continuation of the work that was begun in 2004. This project focuses on the lower 13 km of the Elk River, the main tributary to Upper Campbell Lake, which is impounded by the Strathcona Dam operated by BC Hydro. Over the past 70 years the river has changed from a comparatively narrow, single thread, stable channel to a multi-thread, laterally unstable, aggraded channel. The channel stability of the lower Elk River has been documented by *Galbraith (1973), Karanka and Kellerhals (1980), Kellerhals (1992; 1996), Kellerhals and Miles (1996), Nielsen, 1996, Wightman and Chilibeck (1997)* and *MMA (1999)*. The reports have concluded that the changes in the channel characteristics have resulted from many factors including extensive valley bottom logging, channel relocation or diversions due to road construction, a natural slide in the headwaters of the river, the creation of the Upper Campbell Lake reservoir and the increase in flows in the river due to the construction of the Crest Creek/Heber River diversion. The change in river regime has resulted in a 4 to 7 times increase in the un-vegetated channel width. In a report prepared for BC Hydro, the lower Elk River has been identified as the top priority for restoration works of all the diversion creeks in the Campbell River watershed (Reid et al. 2002).

Hydraulic analyses suggest that prior to 1957, the Elk River was flowing near the upper limit of slope and discharge values for a single thread channel. The combined effects of increasing flow and sediment availability, reducing bank vegetation and changes to channel slope has been an abrupt shift over the 'threshold' to a regime of multiple thread channels from a single one. Un-vegetated gravel deposits are highly mobile and contain little organic matter. In the lower Elk River, the expansive gravel bars are reworked during winter and relatively 'high and dry' during summer, creating unfavorable conditions for the establishment of riparian vegetation. All of these conditions combine to perpetuate the unstable, multi-thread channel form.

The aggradation and change in river regime of the lower river has impacted fish habitat. In an abridged fish habitat assessment Ebell et al. (2004) concluded that pool habitat in the river was considered poor as defined by the criteria set forth in Watershed Restoration Technical Circular Number 8 (Johnston and Slaney, 1996). In the unconfined reaches of the lower river, (reaches 1, 2 and 4) pool habitat constituted only 5 %, 6 % and 4 %, respectively, of the overall lineal reach lengths.

Previous channel morphology studies demonstrated the need for river restoration efforts in the Elk River to focus on restoring channel processes. This project was designed to speed the natural recovery of the river. This is to be done through the soil bioengineering process of live gravel bar staking of select, exposed gravel bars. Soil bioengineering is the use of living plant materials to construct structures that perform some engineering function. Live gravel bar staking is an established technique used to initiate natural successional processes on gravel bars that have developed as a result of excess sediment in the stream (Polster 1999; Atkins et al. 2001). Over time as the stakes grow sediment builds up on the bars until eventually the river no longer tops them during high flows. This forces the river to cut a single channel and speeds the recovery of the gravel bars to productive alluvial forests by encouraging riparian vegetation colonization. In addition to establishing a productive riparian forest the live staking causes the river to increase in depth in order to accommodate the increased volume of water during peak flow events. In the case of the Elk River it is expected that the increased water depth will lead to increased pool habitat and improved fish habitat.

The channel stabilization program was initiated in 2004 at which time a field review determined that the river was beginning to show more natural recovery than had been seen in the past 50 years (MMA, 2004). The recovery consisted of the colonization of many of the exposed gravel areas with deciduous trees that ranged from four to six years in age. It was speculated that the natural recovery might have been a result of the above average precipitation during previous summers. During the field review it was also determined that, while there was some natural recovery occurring, there were still vast areas where the recovery of the system could be sped up through the process of live gravel bar staking. Subsequently three sites were selected for live staking in 2004 and one additional site was selected to be live staked in 2005. During the fall of 2004, sites 2, 3 and 6A totaling 1.86 ha were live staked. A detailed report on the 2004 programs can be found in the report "*Elk River Channel Stabilization Project – 2004*" (Cuthbert and Redden, 2004).

2.0 Goals and Objectives

The goal of this project is to speed the natural recovery of the system and expedite the reformation of a stable, single thread mainstem channel and its associated fish and wildlife values in the lower Elk River. The target at the outset of the project in 2004 it was to live stake 3.5 ha of gravel bars during 2004 to 2006. It is expected that over time the live staking will promote the establishment of riparian vegetation and further accumulation of flood borne materials in treated areas, elevating and stabilizing the gravel bars and forcing the river to scour a narrower and deeper mainstem channel. This will enable the successional establishment of other plant species. The main goals for 2005 were to monitor the progress of the three sites live staked in 2004 in achieving these goals and to live stake and conduct baseline monitoring at the site identified as Site 6B.

3.0 Study Area

The project focused on the lower 13 km of the Elk River, roughly from the confluence of Drum Creek downstream to Upper Campbell Lake (Figure 1). This area contains the most heavily impacted reaches of the river. The entire area lies within Strathcona Provincial Park. Most of the lower 9 km of the river is bordered to the south by Highway 28 and to the north by the now de-built Timberwest Elk River Transport Road (ERT).

The system is known to contain resident rainbow (*Oncorhynchus mykiss*) and cutthroat trout (*O. clarki*) and Dolly Varden char (*Salvelinus malma*). Adfluvial rainbow, cutthroat and Dolly Varden from Upper Campbell and Buttle Lakes also use the river for spawning and to access smaller tributaries for spawning. The area also provides valuable habitat for Roosevelt elk (*Cervus elaphus*).

Sites 2, 3 and 6A which were planted in 2004 are located at 9.8, 8.4 and 3.8 km upstream from the river mouth, respectively. Air photographs with approximate delineations of the sites are provided below in Figures 2, 3 and 4. Maps of the planted sites are provided in Appendix IV. Site 6B is located adjacent to site 6A and can also be seen in Figure 4.

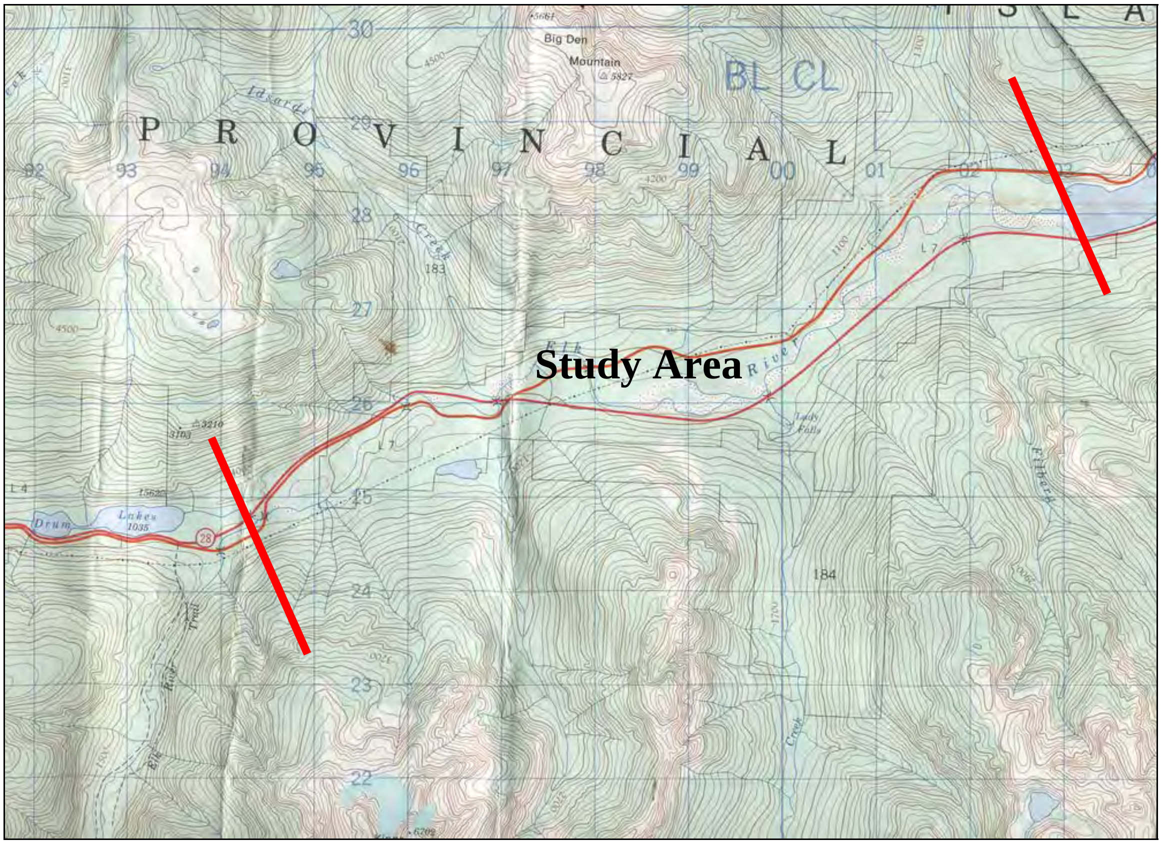

Figure 1. Elk River Study Area.

Figure 2. 1995 Airphoto of Treatment Site 2

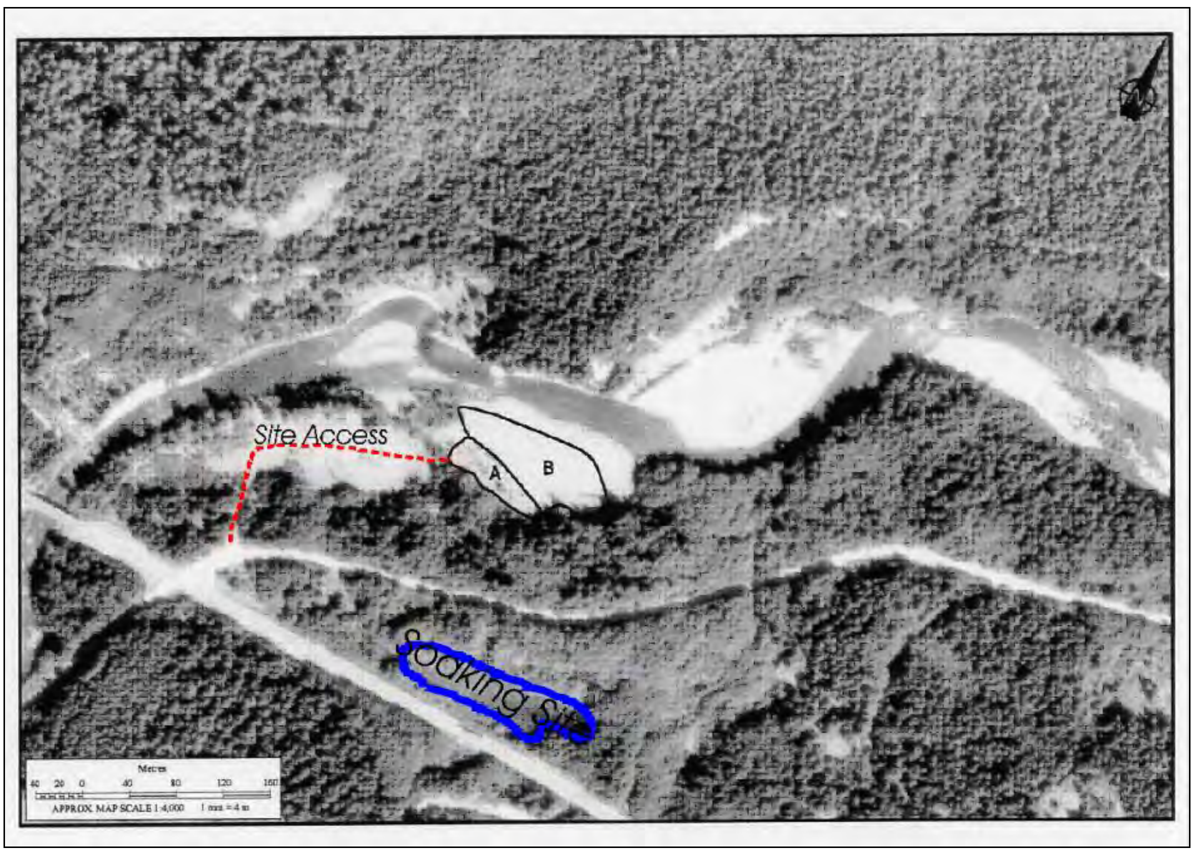

Figure 3. 1995 Airphoto of Treatment Site 3

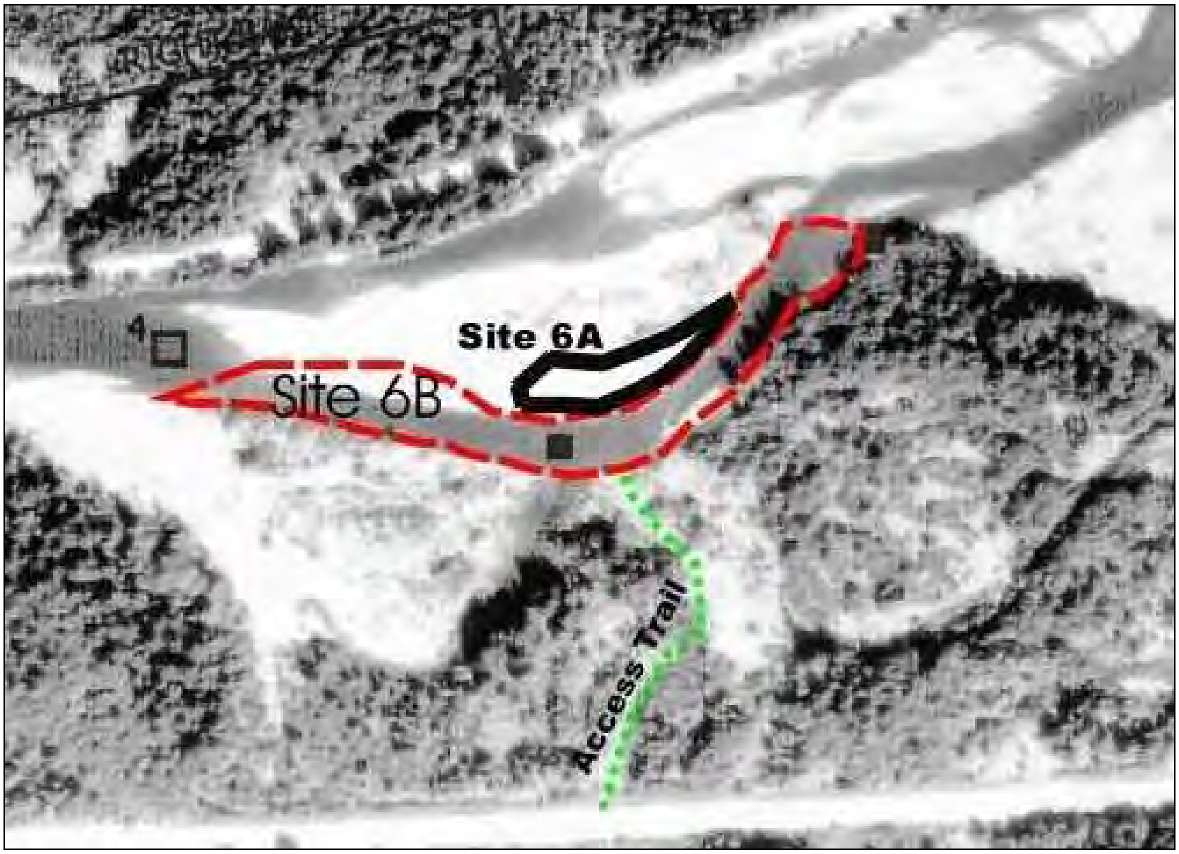

Figure4. 1995 Airphoto of Treatment Site 6

4.0 METHODS AND RESULTS

4.1 2004 SITE MONITORING

Following the completion of the first year of live staking in October 2004 as-built surveys and baseline monitoring assessments were conducted. A total of 51 research plots were established using a piece of rebar driven into the substrate to mark the plot center. Each numbered plot was 3 m in radius. Of the 51 plots, 7 were control plots located outside of the live staking areas. The plot locations have been surveyed and plotted on the maps included in Appendix IV.

4.1.1 LIVE STAKE PERFORMANCE

Based on the baseline surveys conducted in 2004 the average density of planted stakes in 2004 was approximately 17,200 stakes ha^{-1}. The stakes were installed using an excavator with the areas nearest the river planted using 2 m spacing between bucket gaps and 1.5 m spacing between the rows. All other areas were planted using 2 m spacing between the rows and 2 m spacing between the bucket gaps. While the target size for stakes was a minimum of 2.5 cm in diameter many undersized stakes were cut due to the difficulty in finding enough large stakes. Overall, approximately 10,300 full-sized and 6,900 undersize stakes were planted per hectare. Generally 3 or 4 large stakes and several undersized stakes were installed in each bucket gap. During baseline surveys it was determined that the stock consisted of approximately 85 % Scouler's willow (*Salix* *scouleriana)* and Sitka willow (*Salix stichensis*), 6 % black cottonwood (*Populus balsamifera*) and 9 % red-osier dogwood (*Cornus stolonifera*). Due to the lack of foliage on the stakes at survey time, species identification was based on the bark of the stakes.

Assessments of the plots and the live stake performance were conducted on July 28, 2005. At that time plots 19 and 20 located at Site 3 could not be found and it appeared that the rebar marking the plot centers had been removed. It was also found that baseline data had not been collected from one of the plots. This brought the number of functioning plots on the gravel bars to 48, of which 7 were controls. Monitoring recorded stake survival, the number of shoots that had sprouted, and evidence of browsing by wildlife.

A summary of the data collected is presented in Table 1. Once the species were identified based on foliage it became apparent that some of the species identification done in the fall of 2004 based on bark had been incorrect: several of the cottonwood stakes had been incorrectly identified as willow stakes. A total of 123 cottonwood stakes were identified in 2005 as opposed to only 90 in 2004. Subsequently in calculating the survival rates the additional 33 stakes were subtracted from the total number of willow stakes planted in 2004.

Table 1. Live Stake Performance

	Total Stakes Planted in 2004	Live Stakes Showing Growth in 2005	New "shoots" per live stake			% of live stakes browsed	% survival
			1-5	5-10	11+		
Willow (Scouler's and Sitka)	1410	1358	47%	45%	9%	3%	96%
Black cottonwood	90	123	54%	40%	6%	27%	N/A
Red-osier dogwood	158	116	96%	3%	1%	71%	62%
All Species Combined	1781	1597	51%	41%	8%	10%	90%

The live stakes had a high rate of survival (90 %). The survival rate of the willow was highest (96 %), and red-osier dogwood had lowest survival rate (62 %). Due to the unknown number of cottonwood planted in 2004 their survival rate could not be calculated, however, observations indicated that it was high. It was anticipated that there would be significant mortality to the stakes due to browsing from deer and elk. The results indicate that the preferred browse species was red-osier dogwood at 71 % browsed followed by cottonwood at 27 % browsed and finally willow at only 3% browsed (Figure 5). Field observations and monitoring data showed that the mix of species benefited the willow, as the elk and deer focused on the other species allowing the willow flourish. The willow did experience some mortality due to an infestation of what is believed to be willow leaf beetle (P*lagiodera versicolora*). The defoliating beetle was more abundant at Site 2 than the other sites. Generally these beetles are not know to cause tree mortality however it is believed that because the live stakes were newly established the stress caused by the beetles may have led to some mortality. The beetle larvae and the damage it caused the live stakes is shown in Figure 6.

Figure 5. Browsed Red-Osier Dogwood.

Figure 6. Beetle larvae and damage to willow tree.

Average and maximum tree heights for each plot were recorded as a measure of the general health and vigor of the live stakes. Additionally the number of live shoots growing from each stake was recorded. The average height of the stakes was 29 cm. The average maximum height was 53 cm per plot and the maximum height from all of the plots was 72 cm. The majority of these heights were recorded from willow trees. In a few instances cottonwood trees were the highest in the plots while red-osier were consistently the shortest in the plots as a result of browse. As seen in Table 1 the willow stakes had an even distribution of stakes growing 1 to 5 shoots (47 % of stakes) and 6 to 10 shoots (45 % of stakes) per stake. Only 9 % of the willow stakes had more than 10 shoots growing. Cottonwood showed similar numbers, with 54 % of stakes growing 1 to 5 shoots, 40 % with 6to 10 shoots and 6 % with more than 10 shoots. Again, red-osier dogwood did not perform as well, with 96 % of the stakes having between 1 to 5 shoots growing per stake. Photographs of the live stakes performance are provided in Figures 7 and 8. These photos were taken on June 29th, 2005 nearly a month before the vegetation surveys were completed.

Figure 7. Site 3 Live Stake Growth June 29, 2005.

Figure 8. Site 3 Willow Live Stake Growth June 29, 2005**.**

Due to time and funding constraints it was not possible to determine if there was a relationship between the species survival and the diameter of the stakes planted. While it is generally accepted that the larger stakes will perform better than the undersized stakes, in general it was found that the undersized stakes performed better than expected. In future it would be beneficial to measure the planted stakes with calipers to determine whether there is a relationship between size and performance.

Monitoring of the control sites showed that there were no new trees that had established naturally. Likewise, no new naturally established trees were found in the treatment plots.

4.1.2 VEGETATION

During the 2004 baseline monitoring the vegetation present in each plot was assessed and documented based on species and abundance. The 2005 monitoring results showed that there had generally been very little change in species composition or abundance. The amount and type of vegetation that was present varied greatly between plots generally however no plots showed anything more than sparse vegetation at best. The vegetation that was present consisted of mostly small plants such as oxeye daisy (*Chrysanthemum leucanthemum)*, sheep sorrel (*Rumex acetosella)*, Douglas' knotweed (*Polygonum douglasii*), wild strawberry (*Fragaria chiloensis*) and various grasses.

4.1.3 CHANNEL MORPHOMETRY

Following the 2004 live staking program baseline surveys were conducted using a total station. Closed traverse perimeter surveys delineated the sites, and cross-sectional and longitudinal surveys were done through the live staked areas. Maps were generated from the survey data. On June 28th and 29th, 2005 the cross sectional and longitudinal surveys were replicated using a total station. Bench marks established in 2004 were used to ensure the accuracy of the surveys. The profiles were replicated as close as possible to the originals based on compass bearings and distances from known landmarks such as research plot centers. The resulting surveys were plotted on maps along with the 2004 data to determine changes in the topography. The maps (Appendix IV) show that no significant changes in elevation or channel morphometry occurred.

4.1.4 SUBSTRATE

It was expected that as the live stakes grow they will slow the water during peak flow events, causing fine sediments and organics to be deposited, resulting in a gradual shift in the surficial substrate from coarse gravel to finer materials. Baseline 2004 substrate photographs were taken at 16 of the research plots. This consisted of photo-documenting three 0.5 $m^{2.}$ sub-plots from each of the 16 plots. The random sub-plots were established 2.5 m from the center pin of each of the plots at bearings of 120^0, 240^0 and 360^0. The substrate photos were duplicated during the June 2005 site visit. The comparison photos are included in Appendix VII. Analysis of the photos indicates that there was generally little change in the substrate composition. While the photos did not show large changes in composition, evidence of sediment deposition and trapping of small organic debris was found in areas throughout the sites (Figures 9). This was most evident in Sites 2B, lower Site 3 (nearest the river) and throughout Site 6. This indicates that these areas were inundated by peak flows and the live stakes performed as expected.

Figure 9. Fine sediment and small organic debris collecting around live stake.

4.1.5 Photo Documentation

Following completion of the 2004 live staking 3 panoramic photographs were taken at each site. The photographs are perhaps one of the easiest methods to facilitate monitoring the success of the completed plantings. Each photo point was marked in the field with flagging tape and its location is shown on the maps in Appendix IV. On June 29th, 2005 these photos were duplicated. While it is possible to notice the growth of some of the live stakes in the photographs large changes to the sites are not apparent. This is to be expected as the photographs are large scale in order to show as much of the sites as possible. Over time it is expected that, as the trees grow, the changes will become easily observable.

4.2 Site 6B

Site 6B is located approximately 3.8 km upstream from the river mouth and adjacent to Site 6A which was planted in 2004. The site is a seasonally active flood channel located to the right of the main river channel. The prescription for the site was to plant 0.75 ha. Planning for live staking began in the early summer when applications for approval to undertake the work sought from BC Parks, the Department of Fisheries and Oceans Canada (DFO) and Land and Water BC (LWBC).

4.2.1 Donor Stock Collection

The process of donor stock collection began with the selection of donor stock sites. In order to ensure the donor stock was suitable for the growing conditions at Site 6B donor site selection focused on areas located near the treatment site. Through consultation with the BC Transmission Corporation several areas under the power lines were identified as potential donor sites. On September 5th a trip was made to finalize the donor site selection. In total three sites were selected. At that time approval was gained from BC Parks to cut from the selected sites.

Cutting of the stock began on September 19th, 2005. This was performed by a six person silviculture crew from the Mowachaht-Muchalaht First Nation (MMFN) under the supervision of Ian Redden. One to two workers operated chainsaws to cut the trees down. The downed trees were then collected by the remaining workers who de-limbed them using hand clippers. The trees were then sorted and bundled based on their size. The bundles typically consisted of 10 to 20 trees per bundle depending on weight. The length of the de-limbed trees ranged from 2 m to > 4 m. The species collected were primarily Scouler's and Sitka willow as well as some red-osier dogwood black cottonwood and a few bigleaf maple (*Acer macrophyllum*) trees. Given the success of the smaller diameter live stakes planted in 2004 and the difficulty in finding enough donor stock the minimum target size for live stakes was ~ 2 cm diameter. The bundled trees were taken to a small lake located on the side of Highway 28 and placed in the water to soak, as this keeps the trees alive until the planting begins the soaking removes rooting inhibitors. Typically, two truckloads of bundles were taken to the soaking site per day.

Crews cut from the power lines north of the Elk River for 2.5 days and then moved to the power lines on the south side of the river near the Elk Viewing Trail for another 1.5 days. On September 23rd the crew cut from an area adjacent to Highway 28 near the access trail for Site 6. One final day of stock collection near the Site 6 access was performed September 26th at which time the crew size was reduced to three MMFN crewmen.

4.2.2 LIVE STAKING

Live staking began on September 27th and was completed on September 30th. Access to the site for an excavator and pickup was easily gained by reactivating the trail that was used in 2004.

Due to the inherent difficulty of planting in gravel substrate, an excavator was used to install the cuttings. This minimized damage to the stock while planting, and ensured that the cuttings were planted deep enough to survive the dry summer months. The excavator did not dig holes but rather inserted the bucket into the gravel and pulled back the material creating a gap into which the stakes were placed. The excavator then withdrew its bucket allowing the gravel to settle back in place. The excavator worked by backing upstream while planting in successive rows that were spaced 2 m from the previous row and staggered to prevent large open patches in the plantings. The excavator would then reach as far as possible upland from the river to cover as large an area as possible in each row. The cuttings were angled downstream to minimize the potential to snag large woody debris that may be floating downstream during the first season following planting.

Once on-site, it was determined that the area that would benefit from live staking was larger than the 0.75 ha that had been prescribed. Through the combination of spacing the bucket gaps by 2 m between gaps and 2 m between rows and the installation of 4 stakes per gap it was possible to live stake 1.41 ha with a density of approximately 8,600 stakes ha^{-1}. While this is less than the 17,200 stakes ha^{-1} planted in 2004, it is near the 10,300 'full sized' stakes ha^{-1} that were planted in 2004.

While onsite two Caterpillar type machinery tracks were found embedded in the gravel bar. Conuma Excavating removed these metal tracks and disposed of them offsite as an in-kind contribution to the project.

4.2.3 Baseline Monitoring

The baseline monitoring that was conducted at the 2004 sites was duplicated following the completion of planting at Site 6B. This includes the perimeter and profile surveying and subsequent map production (Appendix V), the baseline photographs and the installation of 14 treatment monitoring plots and 3 control plots. Baseline vegetation live and stake assessments were completed at each plot. Substrate monitoring photographs were taken from a subset of 7 of the monitoring plots. As in 2004, photos were taken at 2.5 m from the plot center pin at bearings of 120, 240 and 360 degrees.

5.0 Discussion

While it will likely take several years for the live staking to fully achieve the goals of restoring the gravel bars, the performance of the 2004 sites is considered to be very good. The overall survival rate of 90 % is higher than had been anticipated and the loss to browse is much lower than expected. This is likely due in part to the apparent preference of the elk and deer to browse red-osier dogwood and cottonwood instead of the willow that make up the bulk of the live stakes.

The live staking of Site 6B went well with the area staked being nearly double the prescribed area. While the number of stakes per hectare is fewer than in 2004 given the good survival rate at the 2004 sites it is believed that this should still work well in achieving the project goals. Through future monitoring it will also hopefully provide further information regarding the performance of live staking at different densities.

The Gold River Streamkeepers and students from Gold River Secondary School were scheduled to join the crew onsite to help with the live staking. Unfortunately due to a last minute obligation the Streamkeeper member was unable to attend. As they were supposed to supervise the students, the result was that the students could not attend. It was hoped that the students and Streamkeepers members could attend during the baseline monitoring later in October, however that coincided with the provincial teachers strike further hampering efforts to have the students on-site. Although the Streamkeepers were not able to attend, they have been supportive of this project.

While onsite for live staking at Site 6B the stock donor site used in 2004 was re-visited to visually assess how the regeneration of the cut trees. As expected the trees had been very successful in regenerating and some were well over 1 m high already. This is considered important as the site is in Strathcona Provincial Park, and quick regeneration will help to restore the aesthetics of the site.

6.0 RECOMMENDATIONS

Over time, it is expected that the bioengineering work will cause sediment deposition in the treated areas, stabilize the gravel deposits, and promote the development of a narrower and deeper river channel and successive riparian vegetation. The follow-up monitoring showed encouraging results at the 2004 sites. This monitoring should continue and be duplicated in each successive year for the next four years to allow for the determination of changes in performance indicators including live stake survival, the effectiveness of stakes in promoting sediment deposition and riparian vegetation establishment, changes to surface bed material size and measures of channel morphometry. The information collected through monitoring can be used to plan and conduct future restoration efforts in the Elk River and other watersheds.

7.0 ACKNOWLEDGEMENTS

Bridge Coastal Fish and Wildlife Restoration Program provided financial support for this project. The assistance provided by Roger Dunlop of the Nuu-Chah-Nulth Tribal Council was very helpful in gaining broad support for the project. The Nootka Forest Products crews of the Mowachaht-Muchalaht First Nation worked hard to get the donor stock and complete the planting in the allotted timeframe.

Paul Smith and the Gold River Streamkeepers were very helpful throughout the project providing general support and liaising with the local high school.

We wish to thank Andy Smith of BC Parks who gave his approval to the project and offered his support whenever it was needed. Finally we wish to thank all of the agency representatives and stakeholders who provided letters of support for the project.

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Appendix I. Financial Statement

Elk River Channel Stabilization Project **Project #** **05CA02**

Financial Statement Form

	BUDGET		ACTUAL	
	BCRP	**Other**	**BCRP**	**Other**
INCOME				
Total Income by Source	$41,410	$4,840	$41,410	$3,740.65
Grand Total Income (BCRP + other)	**$46,250.00**		**$45,150.65**	
EXPENSES				
Project Personnel				
Consultant Fees	$27,175	$	$31,502.68	$ 250.65
Gold River Streamkeepers	$	$1,280	$	$
Gold River High School Students	$	$1,600	$	$
subtotal	**$27,175.00**	**$2,880.00**	**$31,502.40**	**$ 250.65**
Materials and Equipment				
Excavator and operator	$5,000	$	$4,503.00	$400
Chainsaw	$500	$	$325	$
MMFN Crew vehicles	$1,500	$	$1,480	$
Meals and Accommodation	$2,875	$	$1,220.75	$
Supervisor vehicle	$2,000	$	$1,455	$
Permits	$250	$	$	$
Field/Safety Gear and supplies	$500	$	$262.35	$750
Survey Gear Rental	$750	$	$433.35	$
Silviculture Equipment	$	$650	$	$650
Subtotal	**$13,375.00**	**$650.00**	**$9,679.45**	**$1,800**
Administration				
Computer Rental	$	$450	$	$450
Courier	$100	$	$20.58	$20
Report Production	$400	$	$206.57	$
Communications	$	$500	$	$500
Payroll Processing/Invoicing	$360	$360	$	$720
Subtotal	**$860.00**	**$1,310.00**	**$ 227.15**	**$1,690.00**
Total Expenses	**$41,410.00**	**$4,840.00**	**$41,410.00**	**$3,740.65**
Grand Total Expenses (BCRP + others)	**$46,250.00**		**$45,150.65**	
BALANCE (Grand Total Income - Grand Total Expenses)	**$0**		**$1,099.35**	

Appendix II. Performance Measures – Actual Outcomes

Performance Measures – Target Outcomes												
Project Type	Primary habitat benefit targeted of project (m2)	Primary Target Species	Estuarine	In-stream Habitat – Mainstream	In-stream Habitat – Tributary	Riparian	Reservoir Shoreline Complexes	Riverine	Lowland Deciduous	Lowland Coniferous	Upland	Wetland
Impact Mitigation												
Wildlife migration improvement	Area of habitat made available to target species	Ungulates, small mammals, amphibians, birds		14064 m^2		14064 m^2			14064 m^2			
Habitat Conservation												
Habitat conserved – general	Functional habitat conserved / restored by other measures (live staking)	RB, CT, DV Ungulates, small mammals, amphibians, birds		14064 m^2		14064 m^2			14064 m^2			
Maintain or Restore Habitat forming process												
Stabilize gravel bars	Area of stream habitat improved by gravel bar stabilization			14064 m^2		14064 m^2			14064 m^2			

Appendix III. Confirmation of BCRP Recognition

THE RECORD

News & Views From Canada's West Coast

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Mail Registration Number 40016049

Restoration of Elk River Continues

MIRIAM TREVIS
THE RECORD

With funding again provided by BC Hydro, under its Bridge Coastal Fish and Wildlife Restoration Program, rehabilitation work on the lower Elk River has been completed for this year. The work was commenced last year in an effort to re-establish the river as a single thread, stable channel.

According to a report from Streamline Environmental Consultants who have been overseeing the work, a series of factors over the past several years have contributed to creating a multi-thread, laterally unstable, gravel in-filled channel in the lower 13 km of the Elk River. These factors include valley bottom logging, a natural landslide, water diversion from an adjacent watershed and channel relocation due to road construction. As a result, the report states that there is now a 4-7 times increase in the un-vegetated channel width resulting in the loss of fish habitat, eroding banks and an unstable channel.

Work on this project commenced last year when crews from the Mowachaht/Muchalaht First Nations commenced a soil bioengineering process call live staking in which deciduous tree stakes are planted in the exposed gravel bars. The live stakes, which were planted at a density of 17,200 stems per hectare, speed the natural recovery process of the river helping to establish productive riparian forests while increasing channel stability. During seasonal floods over the live-staked gravel bars the stakes promote sediment removal from the river water, which in turn increases the elevation of the gravel bars. Over time as the bars become higher they are inundated by floodwaters less frequently and the river is naturally forced to flow in one channel rather than wander back and forth across the valley bottom.

Last year a total of 1.86 ha. was planted at three different sites along the lower Elk River. This work continued in September of this year when an evaluation of last years work was completed together with a planting of a further hectare using primarily willow stakes together with some cottonwood and red-osier dogwood. The study of last years work is showing encouraging results with an 89% survival rate of the stakes.

For a comprehensive report on this project, please go to http://www.bchydro.com/bcrp/completed_projects/04CAB1a.pdf.

Spring 2005 - *Streamline Watershed Management Bulletin* article.

Live Gravel Bar Staking Channel Stabilization in the Lower Elk River

Iain D. Cuthbert and Ian D. Redden

During the past 70 years, the Elk River on northern Vancouver Island has evolved from a narrow, single-thread, stable channel to a wide multi-thread, laterally unstable, aggraded channel. This change was in response to several factors including: valley-bottom logging; channel relocation due to road construction; a large landslide in the river's headwaters; and increased flows resulting from the diversion of water into the Elk River from the adjacent Heber River watershed. The net result: a 4–7 times increase in the unvegetated channel width in the lower 13 km of river and degraded fish habitat because pools infilled, banks eroded, and cover was lost.

Previous channel morphology studies (e.g., M. Miles and Associates 1999) demonstrated the need to restore channel processes in the lower Elk River to expedite the re-formation of a stable, single channel. This project addresses this recommendation and does not incorporate any upland restoration activities that likely will be part of future restoration plans. Based on successful treatments of rivers with similar conditions, such as the San Juan (Switzer 1999), we chose the soil bioengineering technique of live gravel bar staking as the preferred restoration method to achieve our objective. This article describes the application of and lessons learned from live gravel bar staking in the lower Elk River.

Live Gravel Bar Staking: Background

Live staking of gravel bars using willow (*Salix* spp.) and other plant species such as red-osier dogwood (*Cornus stolonifera*) and black cottonwood (*Populus trichocarpa*) can be used to treat river channels that have become aggraded and braided. In live staking, cuttings (stakes) from the selected pioneering species are planted at high density into the gravel bars.

During high flows, the treated areas are inundated; the friction caused by the protruding stakes traps very small woody debris and leads to local deposition of sediment. Each winter, once enough sediment is deposited to cover the protruding stakes, streamflow will top the bars without resistance. In the next growing season, the cuttings will grow and protrude above the gravel bar. This seasonal process of growth followed by sediment and debris accumulation causes the gravel bars to progressively stabilize and elevate (Figure 1). At the same time, the accumulation of fines and organics, such as small woody debris, promotes the establishment of additional riparian vegetation, further stabilizing the bars. Over time the gravel bars elevate, and become inundated less frequently. The streamflow becomes increasingly confined to the main channel, redirecting the river's energy to scouring a narrower and deeper mainstem channel. Polster (1999) discusses live gravel bar staking and other soil bioengineering techniques in detail.

Site Selection

The Elk River, a tributary to Upper Campbell Lake, is located on northern Vancouver Island near the town of Gold River, B.C. The potential treatment sites were first selected by analyzing historical air photos from 1931 to 1995. The main site selection criteria were gravel bars (1) with easy equipment access, (2) in incipiently stable depositional areas, and (3) outside of the most active channel sections that convey high flows. Criteria 2 and 3 were extremely important as live gravel bar staking of the more active channel sections could reduce flood conveyance capacity and possibly accelerate bank erosion or channel shifting (M. Miles and Associates 2004).

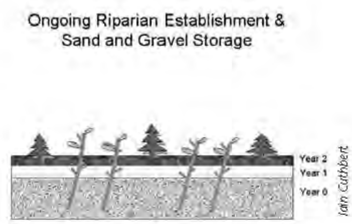

Figure 1. Function of live gravel bar staking.

A June reconnaissance trip finalized restoration site selection, determined site access, and located suitable stock donor and soaking sites. During this trip we discovered that the natural recovery of many of the potential sites identified on the air photos was significant, and included deciduous trees older than 5 years. We theorized that this recovery, the greatest in the previous 45 years, was due to several years with unusually wet summers and smaller than average flood flows. The natural recovery observed was vigorous enough to eliminate several of the potential treatment sites. Thus, three additional sites not identified in


Ian Redden

Figure 2. Assembling limbed poles into bundles.

the office review were investigated in the field.

While many areas would have benefitted from live gravel bar staking, site access became the largest limiting factor. Although Highway 28 parallels much of the river, steep banks from the highway prevented equipment from accessing the river. The only other road in the area that would have provided access to the river had been deactivated for much of its length. As most of the lower river lies within Strathcona Provincial Park, excavator access trail building needed to be minimized to preserve ecological values. In total, three sites were selected for treatment.

Collecting and Preparing the Stakes

The project began in September 2004 with the collection of donor stock from areas close to the restoration sites in Strathcona Park. Stock was collected by cutting down small deciduous trees close to the ground with chainsaws. The donors would coppice and regenerate in the following year. The stakes collected were comprised of 85% willow (Scouler's and Sitka), 6% black cottonwood, and 9% red-osier dogwood. Crew members then collected, topped, and limbed the cut trees. Using high quality, relatively expensive pruning and lopping shears was invaluable, as smaller shears tended to break, disrupting production. The topped and limbed "poles," which ranged from 2 to 4 m in length, were then placed on sawhorses and tied with biodegradable sisal baling twine into bundles of 7–10 stems (Figure 2). Flagging tape was attached to each bundle, with a different colour used for each day. When the weather conditions were cool and wet, bundles were loaded into trucks and taken to the soaking site at the end of each day. During warmer, sunny weather, bundles were taken to the soaking sites throughout the day to prevent desiccation (wilting) and death. The use of a Silva cool-tarp to cover the bundles during collection would have been beneficial during hot, dry weather. Production averaged 2840 stakes per day for a seven-person crew.

The target size for stake collection was 2 cm in diameter or larger. This size is often referred to as the "rule of thumb" as typically anything greater in diameter than your thumb is the desired size. After several days of harvesting it became apparent that the main cutting site would not provide enough stock to plant the treatment areas, and two additional donor sites were located. Also, a limited quantity of stock at the main donor site met the diameter criteria. Due to the shortage of large stock, cuttings that were slightly smaller than 2 cm in diameter were also collected and were referred to as "undersize stock."

The cuttings need to be soaked in fresh water for 7–10 days to remove rooting inhibitors before planting (D. Polster, pers. comm., 2004). One challenge of this project was finding adequate soaking sites, as nearby ponds were shallow and water levels dropped during the soaking period due to warm, dry weather. As a result, bundles had to be repositioned several times to avoid drying out. Beavers added another challenge: they raided the soaking area; removed some of the largest cuttings, stripping the bark and cambium layers from others; and sometimes took entire bundles.

Once most of the donor stock had been collected, the crew split up: one crew continued cutting, while the second crew began planting stakes. The planting crew collected the bundles from the soaking sites, taking the earliest cuttings first; and then transported them to the treatment sites where they were cut with lopping shears into 1 m length stakes in preparation for planting.

Stake Planting

Due to the inherent difficulty of planting in gravel, an excavator with a digging bucket was used to install the cuttings in the coarse gravel bars. The use of the excavator minimized damage to the stock during planting, and ensured that the cuttings were planted deep enough to survive the dry summer. The excavator did not dig holes, but rather inserted the bucket into the gravel and pulled back the material, creating a 1 m wide gap into which the stakes were placed by

Continued on page 12

Continued from page 11

Ian Redden

Figure 3. Crew member instructing student on planting stakes.

hand (Figure 3). The excavator then withdrew its bucket allowing the gravel to settle back in place. The stakes were planted with about three-quarters of their length in the gravel at a 45° or greater downstream angle (Figure 4). Four large stakes and three to five undersized stakes, if available, were placed into each opening, taking about one minute for each opening. While the undersized stakes may not flourish as well as the large stakes, they significantly increased the overall number of stakes planted, which should improve the chances of the project in overcoming mortality due to elk browse.

Ian Redden

Figure 4. Planted stakes.

The excavator worked by backing upstream while planting in successive rows spaced 1.5–2 m apart and staggered to prevent large open patches within the planted areas. The first pass of planting occurred nearest the river channel with the excavator positioned at the edge of the zone to be planted. This ensured that the edge of the row nearest the river was planted parallel to the flow. The excavator then reached as far as possible upland from the river. To maximize the area covered with the available stock, the stakes were planted with tighter spacing and at higher densities on the first pass nearest the mainstem channel where they would likely receive the greatest flows.

Live staking planting began on September 29, 2004, and was completed on October 12. In total, 1.86 ha was planted at three sites at an average density of 17 200 stems per hectare. Planting took an average of 4.5 days per hectare, with a crew of four people working with the excavator.

With the live staking of gravel bars completed, the success of the project will depend on a number of factors, including the growth and survival of the stakes, mortality or stunting due to elk browse, and the response of the treated areas to peak flows.

Monitoring

Long-term monitoring will allow us to assess the success of the live gravel bar staking in achieving the project goals. This information can also be used to help direct future restoration activities. The following measures were taken to assist in gauging project success.

The perimeters of the treated areas as well as longitudinal and cross-sectional profiles were surveyed at each site using a total station survey instrument. Benchmarks were established at each site for future reference during surveys and monitoring. Fifty-one monitoring plots, including seven control plots, were established at various locations within the project area. Each research plot had a 3-m radius (28.3 m^2). A subset of 16 research plots was established to monitor changes in substrate composition. Within each of these 16 plots the substrate in three 0.5-m^2 squares was photographed and documented. Vegetation surveys at each of the 51 monitoring plots included recording the number, species, and size of stakes planted in each plot. Finally, three permanent photo points were established at each treatment site for future monitoring. In 2005, the areas treated in 2004 will be monitored and additional live staking of gravel bars in the Elk River will take place.

While securing funding to study the success of restoration treatments is difficult, monitoring of the live gravel bar staking project is needed to continually improve the selection and successful application of restoration techniques in British Columbia.

Summary of Lessons Learned

- Often spring planting offers several benefits in soil bioengineering. Due to funding timelines, we planted in the fall.
- Use the most recent air photos available for preliminary site selection and reconnaissance.
- Have several stock donor sites selected before beginning cutting. A local Ministry of Forests office or forest company may offer some advice on donor sites.
- Use high-quality lopping shears and hand pruners. The loss in productivity due to the use of poor equipment will cost more than the initial expense of purchasing quality equipment.
- Use lopping shears rather than a chainsaw to cut stakes to length. The chainsaw tended to make rougher cuts and "shred" the bark near the cut end.
- Avoid soaking sites near known beaver populations. The loss of bundled donor stock due to beavers was much higher than we had expected. Using beaver protection such as a rodent fence around the soaking bundles would have prevented some loss.
- Ensure soaking sites have stable water levels. The sudden change from wet weather to several days of dry weather caused one soaking site to dry up, and the bundles required repositioning several times during the soaking period. Covering soaking bundles with Silva cool-tarps may be beneficial in hot, sunny weather.
- Flag bundles collected each day with a different colour flagging tape. This system allows for quick and easy identification of the bundles when collecting them from the soaking site. Use bundles in the order that they were cut.
- While securing funding to study the success of restoration treatments is difficult, monitoring of the live gravel bar staking project is needed to continually improve the selection and successful application of restoration techniques in British Columbia.

Acknowledgements

Mike Miles, a fluvial geomorphologist, assisted the project team by selecting suitable sites for live staking. David Polster, who largely pioneered this soil bioengineering technique in British Columbia, trained the crew to cut stakes to length. A core team of Mowachaht–Muchalaht First Nation forestry workers, supported by volunteers from the Gold River Streamkeepers and Gold River Secondary School, completed this work. The BC Hydro Bridge Coastal Fish and Wildlife Restoration Program funded this project.

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M. Miles and Associates. 2004. Selection of sites for live gravel bar staking: Lower Elk River in Strathcona Park. Consultant's report prepared for BC Hydro, Bridge Coastal Fish and Wildlife Restoration Program, Burnaby, B.C.

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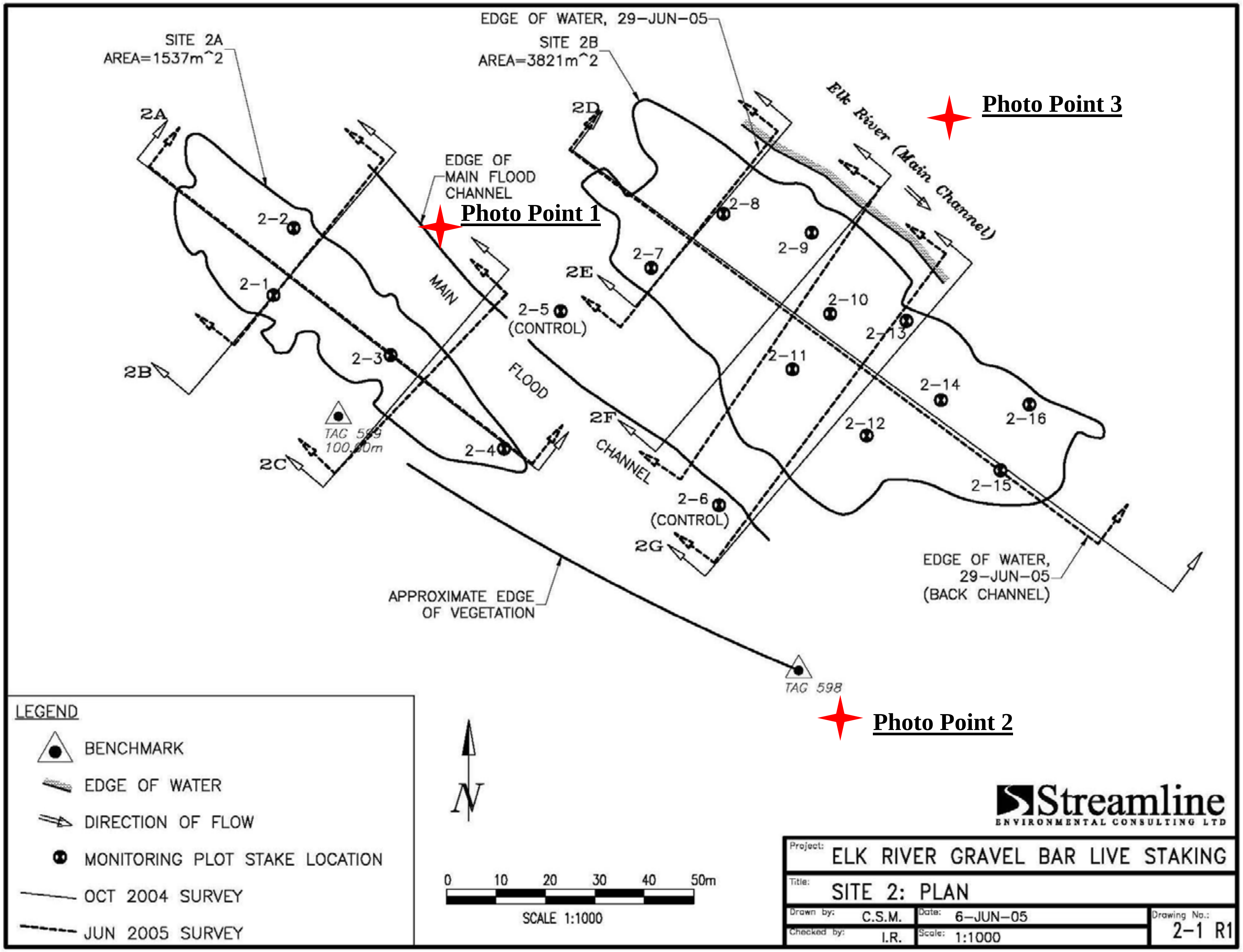
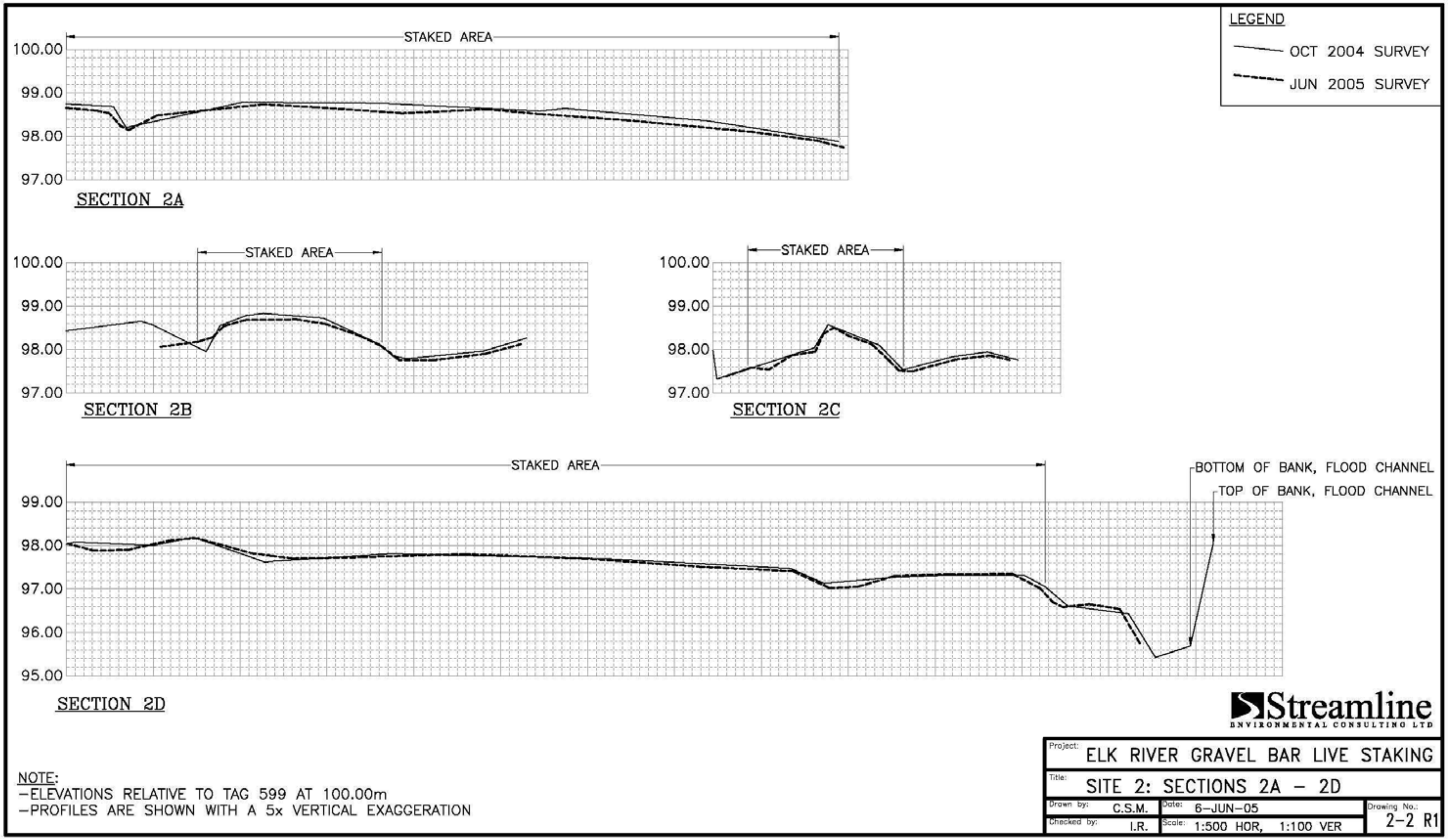
Appendix IV. 2004 vs 2005 Maps of Treatment Sites 2, 3, 6A

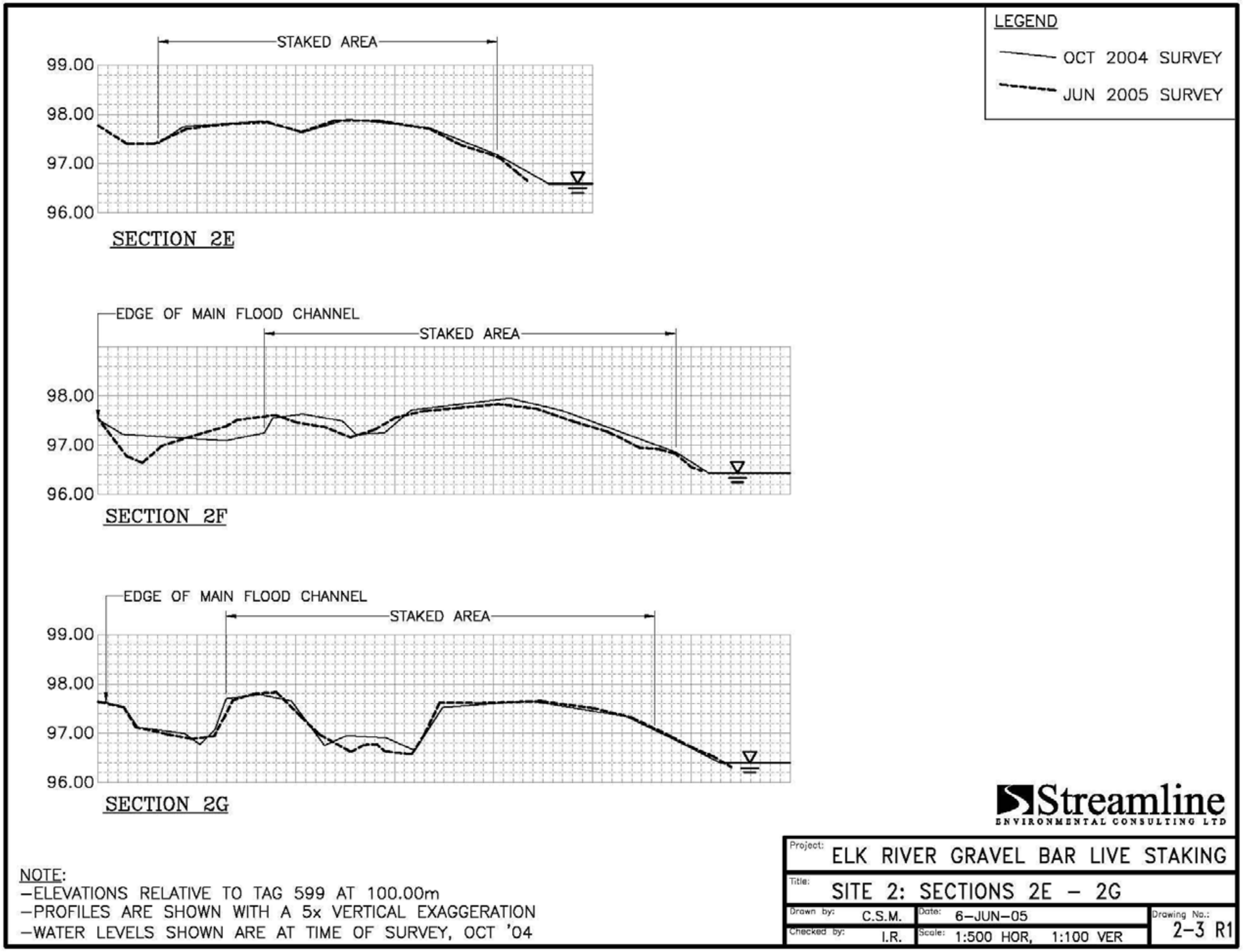
Site 2 2004 vs. 2005 Planimetric Map



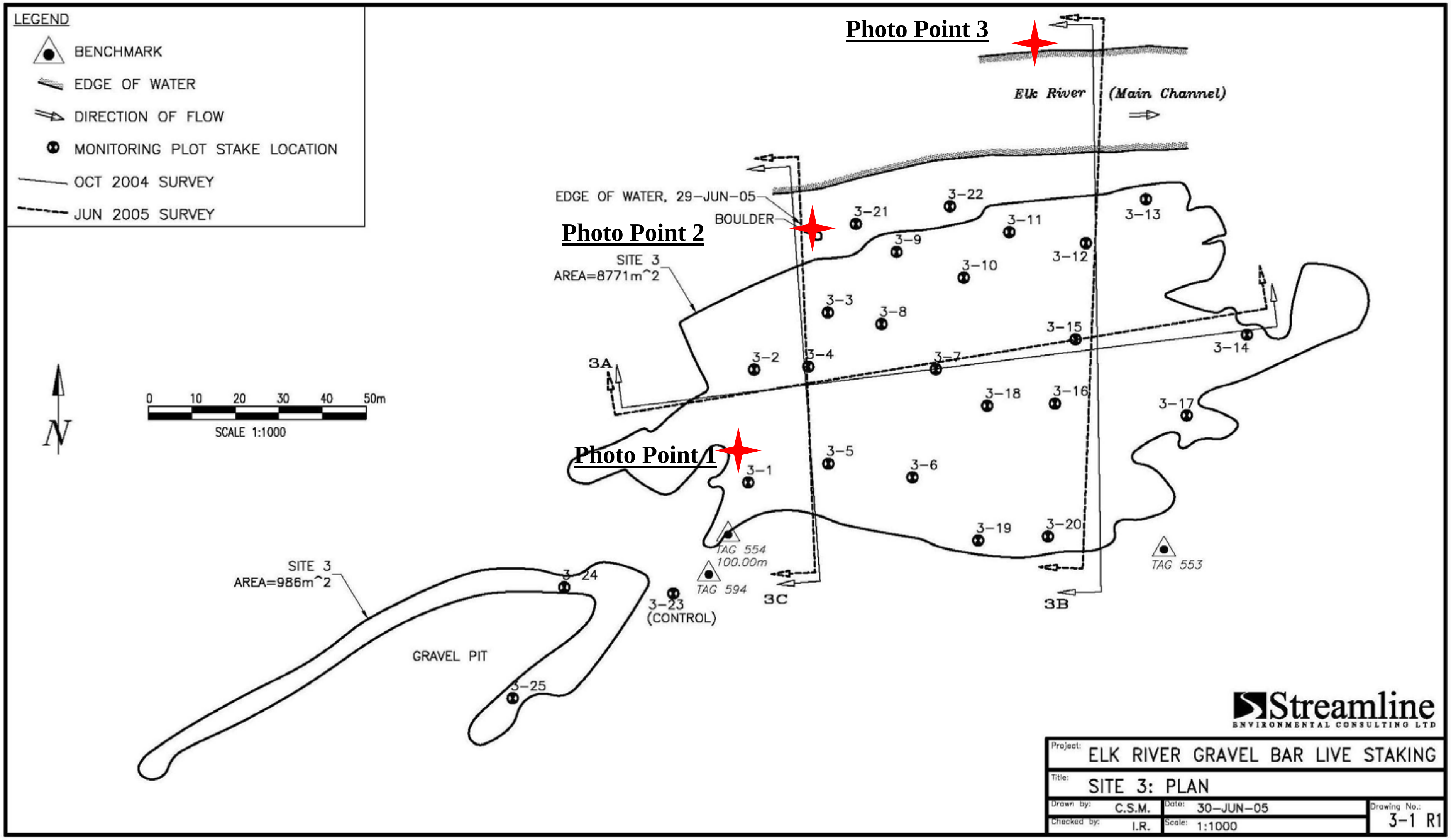
Site 2 2004 vs. 2005 Cross Sections 2A-2D Map



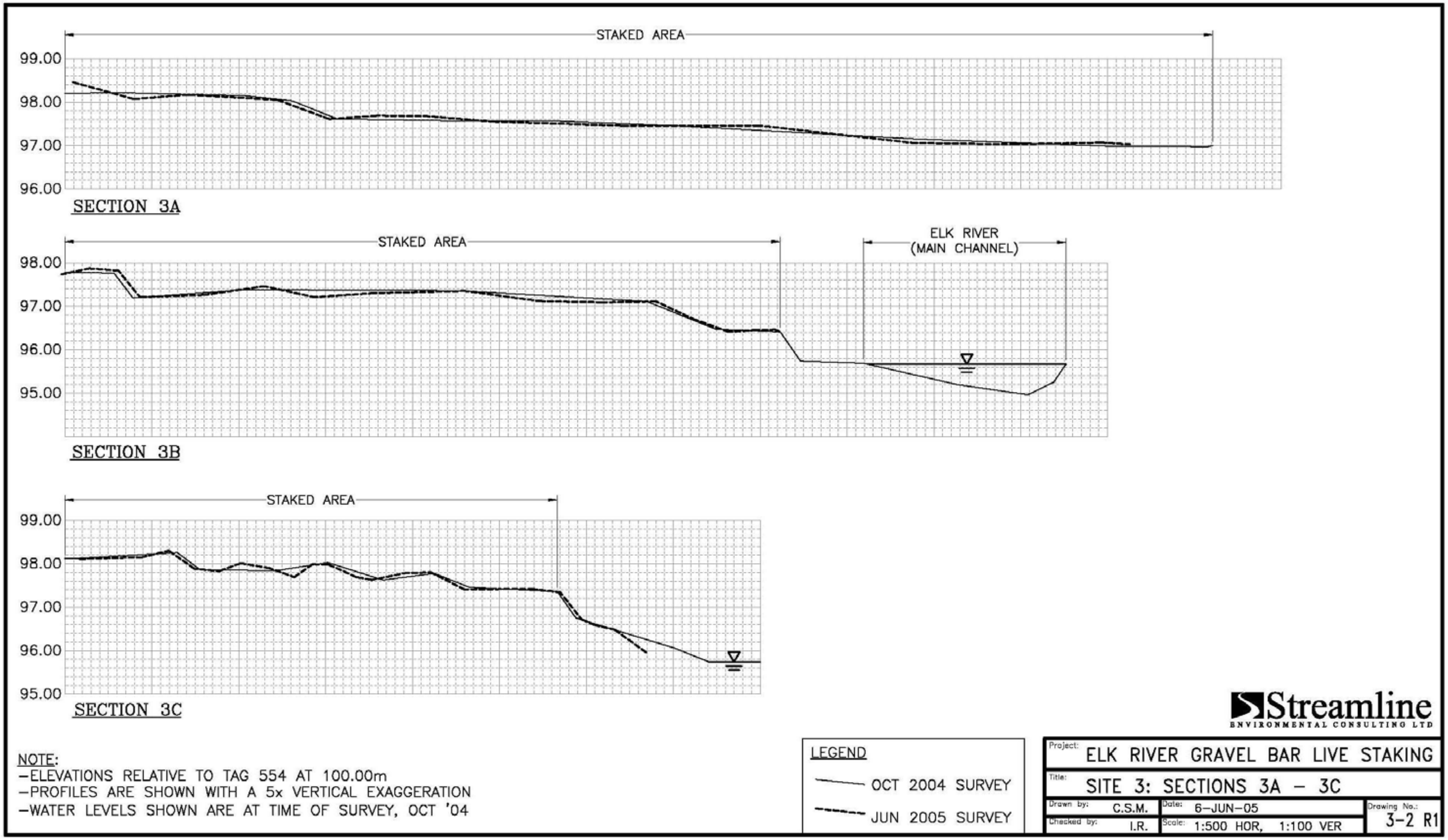
Site 2 2004 vs. 2005 Cross Sections 2E-2G Map



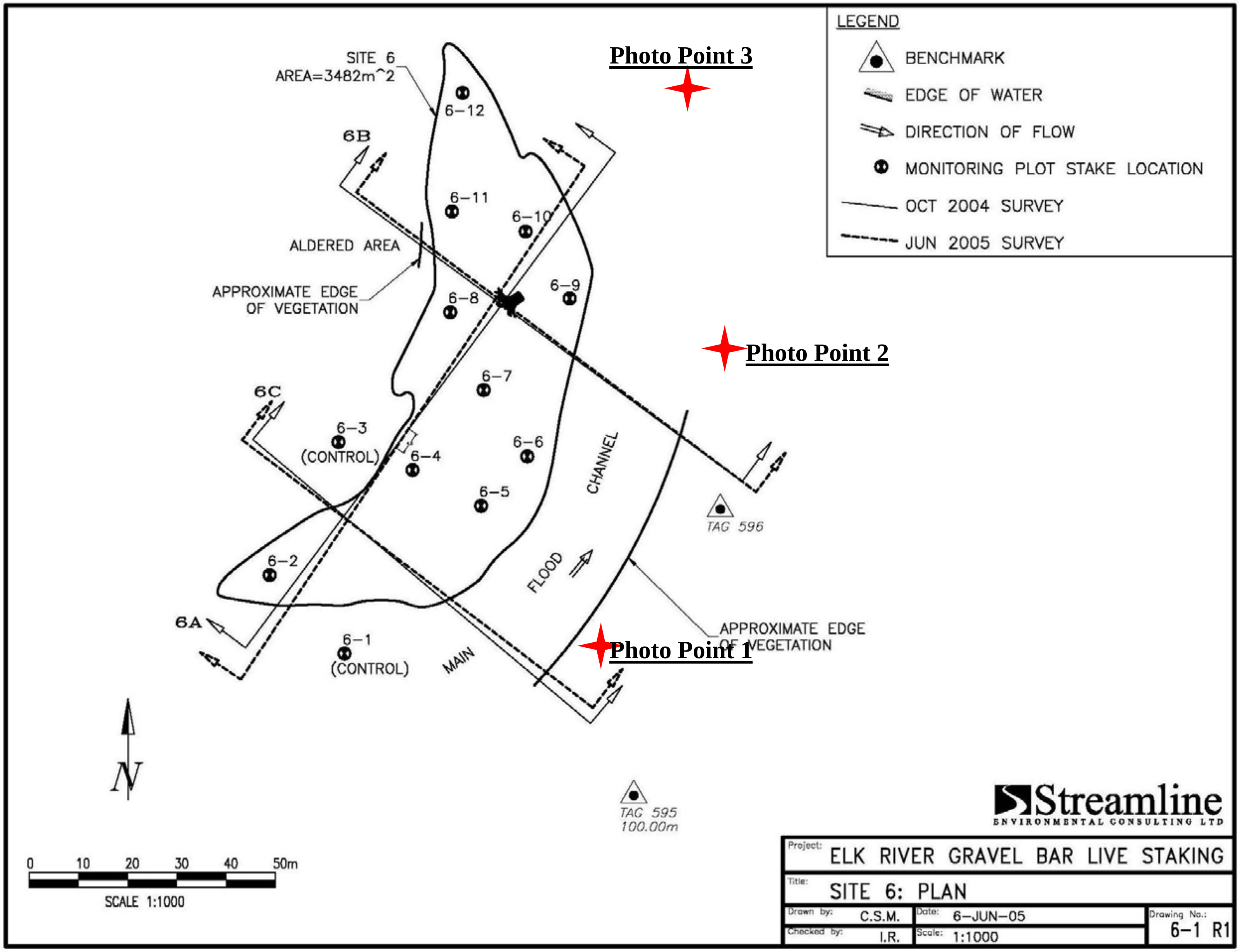
Site 3 2004 vs. 2005 Planimetric Map



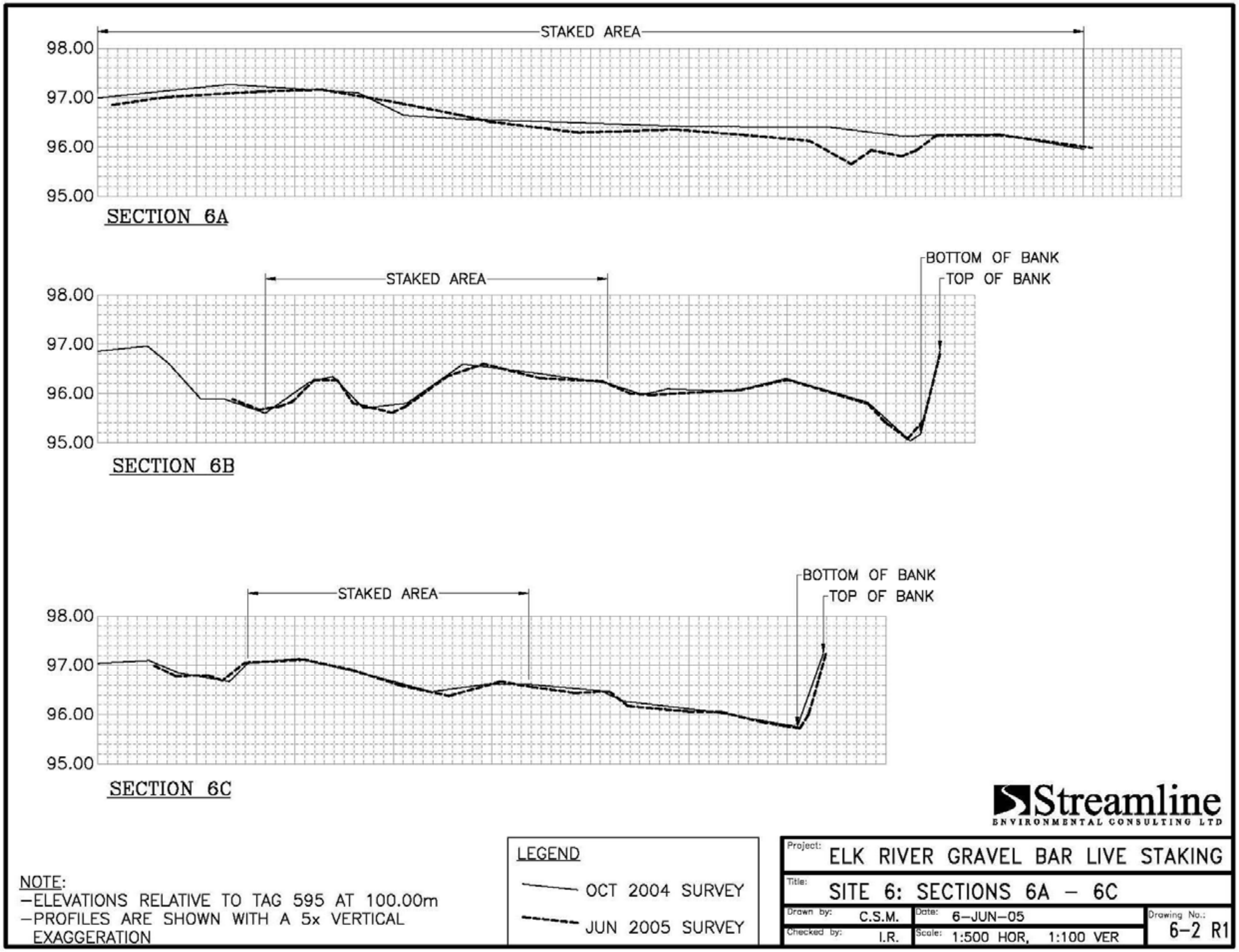
Site 3 2004 vs. 2005 Cross Section Map



Site 6A 2004 vs. 2005 Planimetric Map

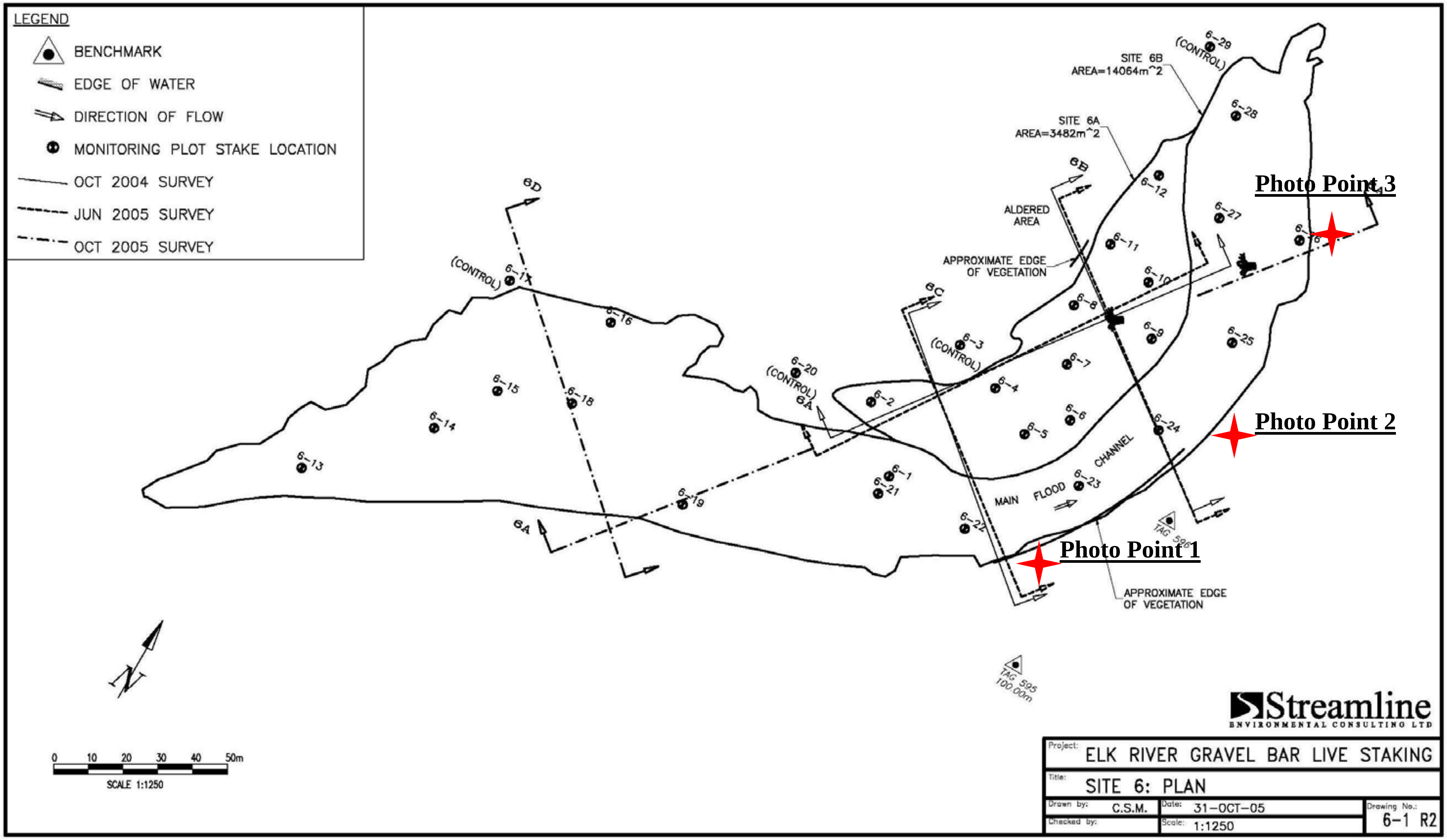


Site 6A 2004 vs. 2005 Cross Section Map

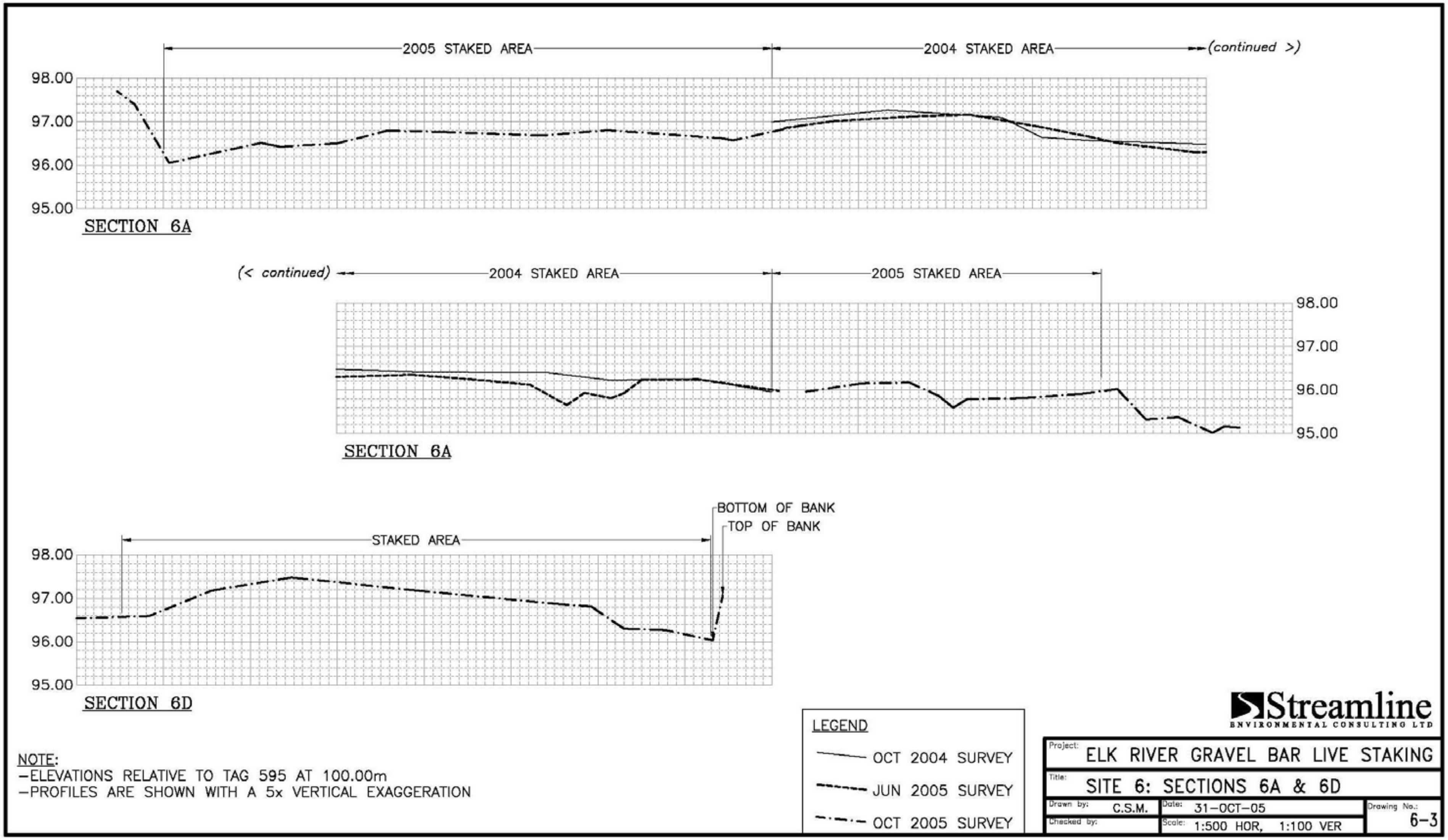


Appendix V. 2005 Maps of Treatment Site 6B

Site 6A Baseline Planimetric Map



Site 6A 2004 vs. 2005 Cross Section Map



Appendix VI. Treatment Site Panoramic Photographs

Site 2A – Photo Point 1 October 2004

Site 2A – Photo Point 1 June 2005

Site 2B – Photo Point 2 October 2004

Site 2B – Photo Point 2 June 2005

Site 2B – Photo Point 3 October 2004

Site 2B – Photo Point 3 June 2005

Site 3A – Photo Point 1 October 2004

Site 3A – Photo Point 1 June 2005

Site 3 – Photo Point 2 October 2004

Site 3 – Photo Point 2 June 2005

Site 3 – Photo Point 3 October 2004

Site 3 – Photo Point 3 June 2005

Site 6 A+B– Photo Point 1 October 2004

Site 6 A+B – Photo Point 1 June 2005

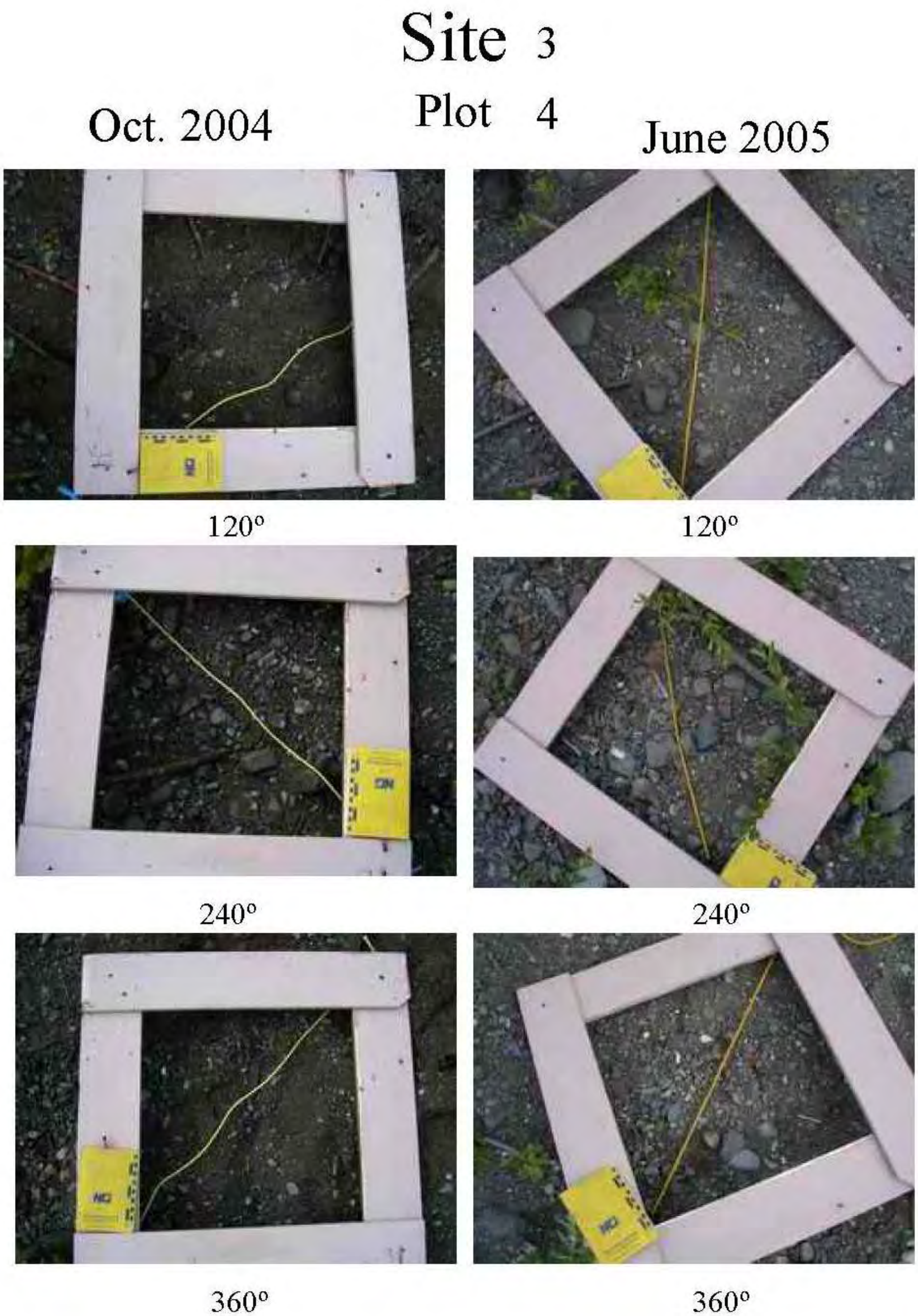
Site 6 A+B – Photo Point 2 October 2004

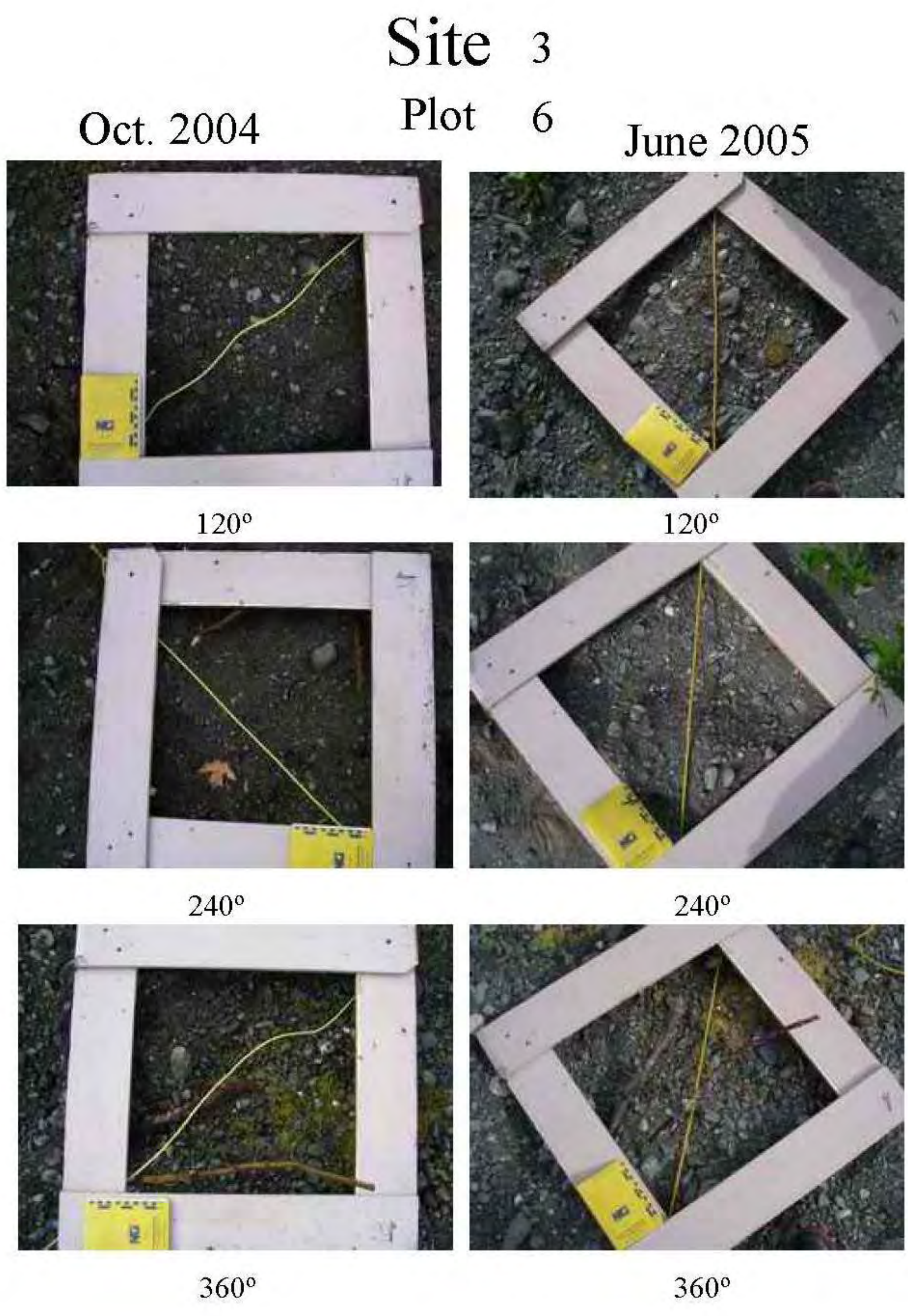
Site 6 A+B – Photo Point 2 June 2005

Site 6 A+B – Photo Point 3 October 2004

Site 6 A+B – Photo Point 3 June 2005

Appendix VII. 2004 vs 2005 Substrate Plots



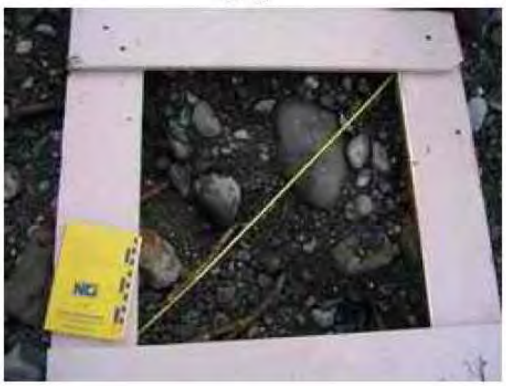

Site 3
Plot 6
Oct. 2004
June 2005
120°
120°
240°
240°
360°
360°

Site 3

Plot 9

Oct. 2004 | June 2005


120° | 120°




240° | 240°


360° | 360°

Site 3

Plot 12

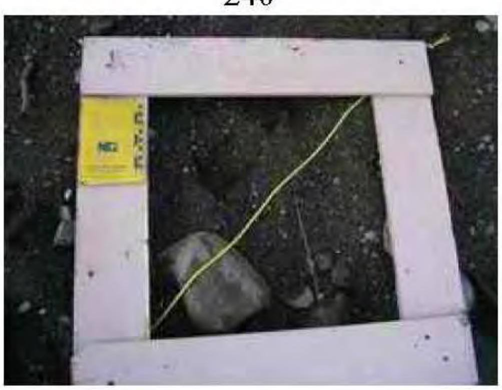
Oct. 2004 | June 2005

120°

120°

240°

240°



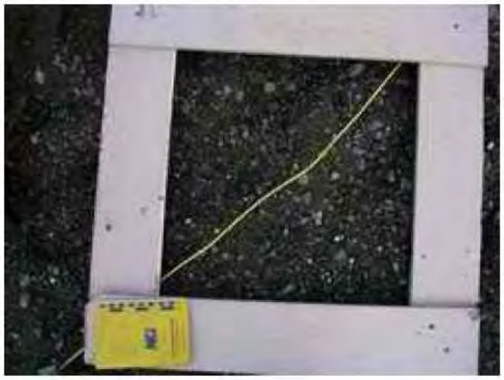
360°

360°

Site 3

Plot 16

Oct. 2004 | June 2005



120°

120°

240°

240°

360°

360°

Site 3

Plot 22

Oct. 2004 | June 2005

120°

120°

240°

240°

360°

360°

Site 6

Oct. 2004

Plot 1

June 2005

120°

120°

240°

240°

360°

360°

Site 6

Plot 4

Oct. 2004

June 2005

120°

120°

240°

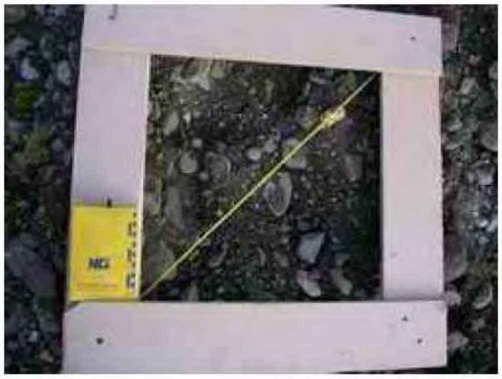
240°

360°

360°

Site 6

Plot 9

Oct. 2004	June 2005
	
120°	120°
	
240°	240°
	
360°	360°

Site 6

Plot 11

Oct. 2004

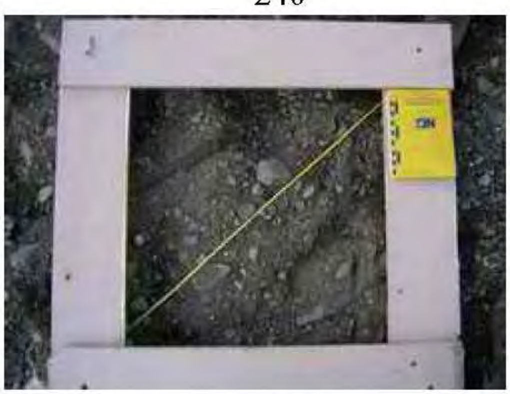
June 2005

120°

120°

240°

240°



360°

360°

Site 2

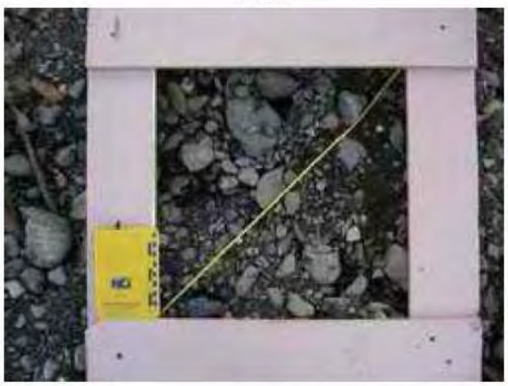
Plot 2

Oct. 2004

June 2005

120°

120°



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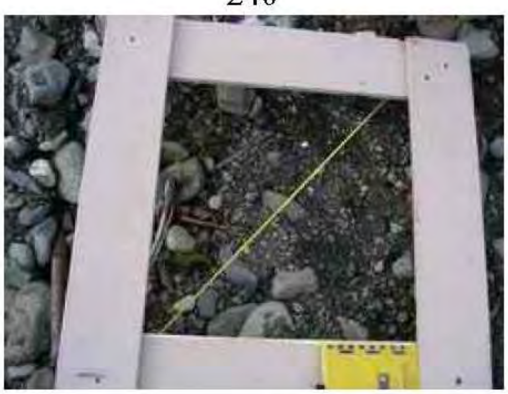

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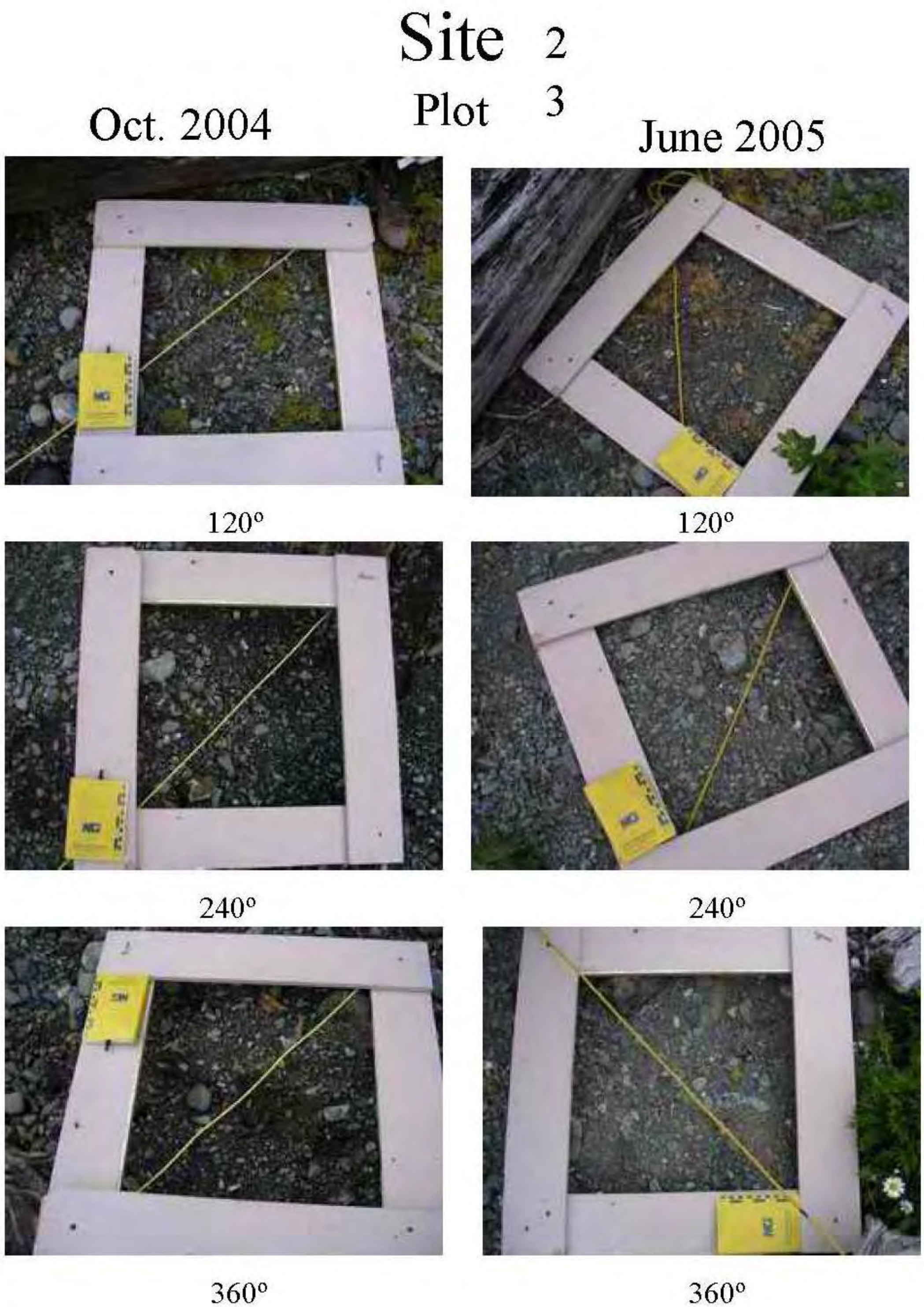

Site 2
Plot 3
Oct. 2004
June 2005
120°
120°
240°
240°
360°
360°

Site 2

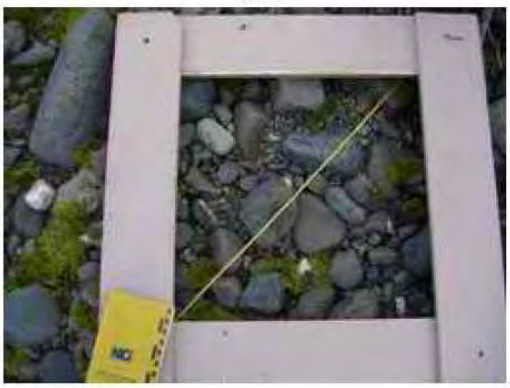
Plot 5

Oct. 2004

June 2005

120°

120°



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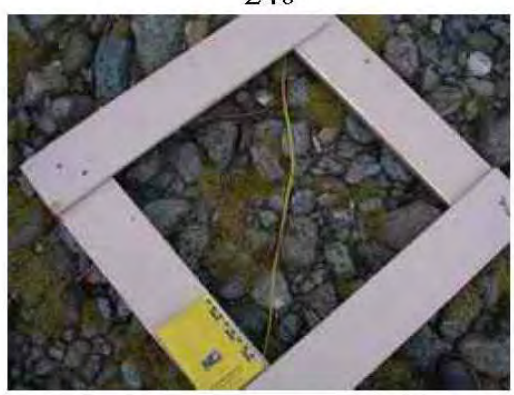

360°

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Site 2

Plot 9

Oct. 2004

June 2005

120°

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240°

360°

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Site 2

Plot 10

Oct. 2004

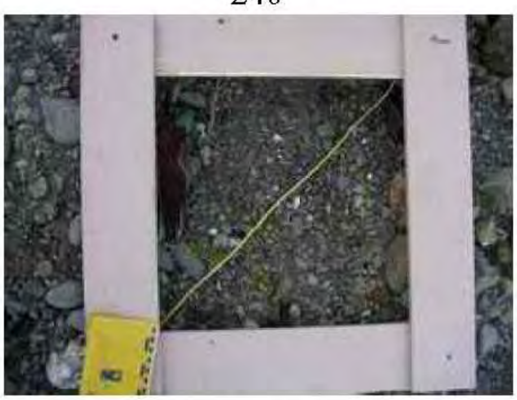
June 2005

120°

120°

240°

240°



360°

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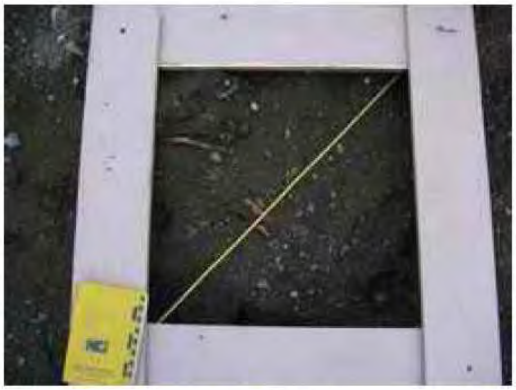
Site 2

Plot 12

Oct. 2004

June 2005



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