**Bio-engineering and Bio-technical Techniques in Streambank Stabilization**
**TAC, Education Achievement Award Nomination Submission**

## Introduction

Alberta Transportation (AT) is involved in highway infrastructure construction and maintenance. Construction and maintenance of roads and bridges often involves land disturbance and if not properly managed may result in erosion. The movement of silt and deleterious materials into water courses and bodies can result in degradation of fish habitat and the aquatic environment. Society is growing environmentally aware and the need for proper stewardship and respect of environmentally sensitive terrain has become a major design consideration. Going beyond simple due diligence requirements, AT as an owner, have taken steps to provide leadership in developing, promoting and constructing environmentally sensitive project outcomes.

AT made a commitment in 2003 to integrate environmental impacts into the Department's decision making process through the adoption of a department-wide Environmental Management System (EMS). The Department's EMS extends consideration of the environment into policy development, guidelines and procedures, and day-to-day practices. Also in 2003 the Department issued *Design Guidelines for Erosion and Sediment Control for Highways*. These guidelines included numerous Best Management Practices (BMPs) for erosion and sediment control (ESC). At the time many BMPs were new to Alberta Transportation, including several bio-engineering techniques.

When the EMS and ESC guidelines came out, there was a lack of industry familiarity, design experience and confidence with the new bio-engineering techniques. This resulted in a general reluctance to incorporate these innovative methods into civil project designs. Issues of warranty, contract specifications and contractor acceptance further complicated matters. If bio-engineering methods were to be used on department projects it was clear that Alberta Transportation would have to take the initiative and leadership to train the road building industry. In 2005 this training was initiated. Using existing eroding streambank sites, a bio-engineering design was developed, and a workshop incorporating both classroom and hands-on field training was completed. Since then three more bio-engineering based workshops have been completed with more than 180 participants having learned how to design using bio-engineering techniques, and how these designs are physically integrated into real life project sites.

In order to obtain the widest support from the stake holders, the training was collaborated with Alberta Environment, Department of Fisheries and Oceans (DFO), Alberta Roadbuilders and Heavy Construction Association (ARHCA), Consultant Engineers of Alberta (CEA) and Centre for Transportation Engineering & Planning (C-TEP).

John McCullah, of Salix Applied Earthcare, Sacramento (www.salixaec.com) was the trainer for the workshops. He is widely respected as a practical hands-on teacher, a

supportive trainer, consultant and conservationist. His E-SenSS (Environmentally Sensitive Streambank Stabilization) CD which features such techniques as vegetated riprap bent-pole method, cross vanes and double cross vanes, was introduced to the participants. Each of the training sessions was professionally filmed and produced into a training video, and made available to the public at modest cost through his website. This CD has won John McCullah the winner of the 2005 International Erosion Control Association Excellence in Technology Award. AT is proud to have played a part in his award.

**Innovation and unique contribution to education and training**

Work near water bodies often entails the installation of hard armour shoreline protection, heavy riprap and gabion structures. These methods are tried and true and provide a technically adequate solution to streambank stabilization problems. However, these conventional methods are costly, non-sustainable, non-environmental supportive, and aesthetically unattractive. Bio-engineering and bio-technical techniques are quite different. These techniques are environmentally friendly and sustainable, provide aquatic and riparian habitat, become stronger with time, and are aesthetically pleasing. Bio-engineering refers to the use of plants to arrest and prevent slope failures and erosion. Bio-technical slope stabilization is the combined use of mechanical elements (or structures) and biologic elements (or plants) to arrest and prevent slope failure and erosion.

The root structure developed by live plants binds soil and inhibits soil erosion. Plant foliage reduces the impact of raindrops, and plant respiration help to absorb moisture from hillsides. Plants thereby improve slope stability by controlling the groundwater table within the slope, and the root mass provides structural resistance to shallow slope movement. Plants are flexible and self-repairing, and gain strength over time.

Two project locations have been identified for the workshop and field hands-on training – Hwy 734 Pembina River and Hwy 2 Willow Creek.

**Hwy 734 Pembina River (2005, 2006)**

This highway, historically referred to as the Forestry Trunk Road, runs north-south along the Rocky Mountain foothills. The Forestry Trunk Road is used year-round by resource companies and the forestry industry, and by a growing back-country tourism industry during summer months. For 15 km or so a mountain stream called Pembina River parallels Hwy 734 and meanders back and forth occasionally encroaching the highway. High flows cause the river to migrate laterally as it naturally erodes streambank materials or is directed by flood debris.

In 2001 a dozen or so areas where the Pembina River was actively eroding the stream bank in close proximity to the highway were identified. These sites were prioritized for repair based on risk and severity factors. Two sites in particular were targeted for repair in 2005 where the eroded bank was within 2 m of the edge of the road and where a

portion of the highway was being undermined by the river erosion. A consultant, Thurber Engineering, was engaged to prepare designs for remediation of these two sites. Rather than repair these sites with heavy riprap that would in essence sterilize a portion of the streambank, it was decided that these two sites would provide near ideal locations for a bio-engineering solution which could be coordinated with a training workshop. Salix Applied Earthcare was added to the design team and helped to develop the bio-remediation concepts and prepare the training workshop elements of the project. Thurber fine tuned the design concepts, prepared a tender package and drawings, and did much of the local preparation work for the workshop. This was one of the first projects tendered with specific bio-engineering methods, and included special provisions notifying the contractor that they would have 60 or so workshop participants descending on their site for a two day period. The contractor, Farlinger and Associates, rightfully bid this into his costs, assuming that all the work done by the course participants would have to be redone to meet the project specifications.

AT's first 3-day classroom and field workshop on bio-engineering and bio-technical streambank stabilization techniques was held in 2005 with 67 registrants (28 AT staff, 21 consultants, 11 DFO staff, 2 City of Edmonton staff, contractors, materials suppliers and other stakeholders). Day 1 of the workshop was reserved for classroom training, where the basics of erosion and sediment control were reviewed, and participants learned about ESC BMPs that would be implemented during the field training. At the end of the first day, a safety briefing was done by the contractor to make participants aware of what equipment was being used, required safe work procedures and what protective gear was required.

On day 2 and 3 of the training, participants were shuttled to and from the field training site for the one hour trip along scenic gravel roads in buses. The course participants enjoyed crisp mountain air while they cut and trimmed willows branches, and installed the various bio-based ESC measures, such as: - live stakes harvesting, rock vanes, longitudinal peaked stone toe protection (LPSTP), live staking, live siltation, branch layering, brush mattress, root wad revetment, vegetated mechanically stabilized earth (VMSE) and vegetated riprap (bent pole method/willow bundle method). Finally, erosion control BMPs were applied on all disturbed land – consisting of hydro-seeding, and straw and coir erosion blankets. A new product consisting on blown compost was showcased, for the application of compost blankets, berms and logs. All participants had opportunity to do as much, or as little physical work as they were comfortable with. John McCullah guided the participants, and the contractor, through the many techniques and worked with the contractor and consultant to field fit the design. In the end, little if any work of the work done by the participants had to be redone.

A similar format 3-day workshop was conducted in 2006 at other sites along Hwy 734 Pembina River with a total of 45 participants attended. The benefit to returning the workshop to the area was the chance to revisit the sites that were completed the previous year, to see how the various techniques were performing, and to appreciate that these techniques do work. A further 44 students participated in the second

workshop. The 2006 AT Minister's Award for Transportation Innovation was awarded to the project.

Staging the training is not without challenges:

- Workshop venue – matching a suitable field training site with classroom facilities
- Safety – having 70 course participants contained in a small work area presented traffic accommodation concerns for the contractor. Course participants went through the contractor's mandatory field training and safety issues. Site Hazard Assessment and OH&S issues reviewed prior to going on site. Two registered first-aiders stayed with the group all the time. The nearest hospital was notified and an evacuation plan prepared. Since the field site was a dead zone for cell phones, a satellite phone had to be used. Potable water, portable toilets and a warm up trailer was provided. Waders, life jackets, safety ropes and first aid kits were on site. A waiver was signed by participants to protect the department against injury liabilities.
- Contract tendering difficulties – the unique combination of untried ESC designs, the coordination of the construction with the training session and rapidly changing water levels presented a significant challenge for our consultant to develop a tender document, and for the contractor to provide a bid price. The contractor's perception of risk heightened due to a heavy rainfall during the tender preparation period which resulted in very high river levels and an increased cost assigned to 'isolation' of the works as required by DFO. As it turned out the water levels dropped rapidly prior to actual construction and no significant isolation costs were incurred.
- Water quality monitoring – To comply with DFO requirements, a professional fish biologist was hired on site to monitor water turbidity and sediment deposition during construction. Knowing that DFO officers would be on site during the field training added to the contractor's, and the department's anxiety. The biologist provided workshop participants with additional hands-on training to take turbidity readings and samples.

**Hwy 2 Willow Creek (2008, 2010)**

Highway 2 is a major north-south provincial highway. Willow Creek undercuts a river bank at a location just north of Fort McLeod, and has caused large-scale slope failure. The scarp from one slope failure encroaches on to the highway right-of-way and was near to the clear zone of the highway. An engineering assessment determined that continuous undercutting of the river bank would cause progressive and faster deterioration of the slide. Proactive measures were therefore required to protect the road. As a continuation of the department's bio-engineering training, it was decided to also incorporate an enviro-friendly design and workshop at this site. The change in location to southern Alberta was expected to bring in new participants, and the drier southern Alberta climate was expected to be a more extreme test of the bio-engineering techniques.

Similar to the Pembina River sites, 3-day classroom and field workshop on bio-engineering and bio-technical streambank stabilization techniques was held in 2008 (40 participants) and 2010 (25 participants), covering consultants, regulators, contractors

and suppliers. As before a contract to repair the bank and slope was tendered to include bio-engineering design and the training workshop. In this case AMEC Earth and Environmental were the design consultants, again with input from Salix Applied Earthcare (John McCullah). The Centre for Transportation Engineering and Planning (C-TEP) organized both of the Willow Creek workshops, and John McCullah was again the instructor.

Similar streambank stabilization techniques were applied to the Willow Creek project, however, new BMPs such as soil nailing, ArmorMax system, excelsior rolls, and Flexterra hydromulch were applied to stabilize the slope and a deeply eroded gully. Compost berms and blankets were also applied at the base of the slope to prevent erosion. The compost also passed a certification process to ensure it is environmentally safe.

**Workshop outcome**

Similar to the Pembina River sites, both the repair work and workshops were successful and highly praised. Many participants brought these new techniques back to their engineering offices and made presentations within their offices. The workshop outcome was presented to Agriculture and Agri-Food Canada and the PFRA (Prairie Farm Rehabilitation Administration) to federal staff in their national conference in Regina in 2006.

Since the repair of the locations along Hwy 734 Pembina River these sites have been proposed by the Hinton FERIC group (Forest Engineering Research Institute of Canada) to be included in a proposed interpretive highway along the scenic foothills.

John McCullah himself has written papers and made presentations of his Alberta training experiences at the IECA (International Erosion Control Association) conferences. He has also shown these educational training videos on his Alberta experiences in “the world’s first television series dedicated to the Erosion and Sediment Control” Dirt Time series (www.watchyourdirt.com) and widely distributed them throughout the USA for educational training purposes.

Consultants have begun to include these techniques in streambank and slope restoration project designs. Regulators are now familiar with and more comfortable with these techniques. Contractors are also becoming familiar with the estimating and construction aspect of bio-engineering projects. In summary the industry has moved forward in the acceptance and capability to use bio-engineering methods, the ability to produce environmentally sustainable and sensitive designs, and the ability to implement these designs.

**Key individuals involved**

Bio-engineering and Bio-technical Techniques in Streambank Stabilization Workshops started out as a collaboration among Alberta Transportation, DFO, consulting

engineers, contractors and material distributor. Key individuals involved from Alberta Transportation throughout the four training workshops were: Roger Skirrow, Don Snider and Fred Cheng. The workshop instructor was John McCullah while James Swirsky of Blink Productions produced the training videos. For the Pembina River workshops, other key contributors were Cliff Corner of AT, Shane Petry from DFO, Don Law and Ken Froese of Thurber Engineering, Rick and Martha Farlinger from Farlinger and Associates, and Gil Barber from Cascade Geosynthetics. For the Willow Creek workshops, other contributors were Ross Dickson of AT, Liv Hundal, Lloyd Madge, Katy Curtis and Andrew Bidwell of AMEC Earth and Environmental, Neil Little of C-TEP, and Harvey Leslie and Trevor Forbes of Mesken, the project contractor.

## Conclusion

The interest and enthusiasm of participants confirmed the department's commitment to encourage and accept the use these innovative environmentally friendly ESC methods. Course feedback was very favorable and a follow-up course is being considered. Interaction between AT/consultants/DFO was encouraging and the casual course setting offered ample opportunity to gain perspectives into each stakeholder's point-of-view. The project demonstrated that it is possible to construct along a river bank without the use of costly isolation techniques. Several consultants indicated that they would try to incorporate some bio-designs into future projects. Training videos funded through the workshop proceeds are now available for anyone to purchase, widening the scope of influence and spreading the benefits of bio-engineering methods beyond Alberta's borders.

Classroom workshop in 2005


Vegetated mechanically stabilized earth (VMSE) Pembina River, 2005

Live siltation technique

Placing blown-on compost blanket

Students at work – Willow Creek


Group Photo – Willow Creek, 2008

Willow Creek site, before - 2006

After - 2009