ABSTRACTS

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Riparian Rehabilitation

Techniques and Approaches to Riparian Restoration

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The simplest and most cost-effective approach to watershed restoration is to protect the system before any damage occurs, and to allow the system to remain in as natural state as possible. Unfortunately, this has not been the case, and many of our systems are already degraded. As a result, it has been necessary to use many approaches and techniques to restore these degraded systems. These attempts have met with varying degrees of success on various levels.

Although hard armouring of an eroded site has been a favoured option, this unfortunately provides little benefit to the stream itself. Fish usage of this type of site is generally poor and it takes many years for vegetation to regenerate. In addition, the transference, rather than dissipation, of stream energy causes further problems downstream. Rock groin structures have also been used in many areas and are effective in redirecting the watercourse away from a bank. Gradually, such "hard" techniques have become softer in recent years: for example, habitat structures have been incorporated, and planting techniques developed to improve a rip-rap project. Other techniques are now incorporating a large vegetation component; however, they also balance the use of geo-textiles, rock, and woody materials, depending on the site. A factor that contributes to the success of these projects is the establishment of a well-vegetated riparian corridor through fencing and planting programs. Fencing the riparian corridor is considered extremely important as it reduces pressures on the area by restricting livestock access and establishing a physical barrier for other works. The corridor aids in ensuring the long-term stability of the stream while the vegetation recovers.

Eventually, this vegetation will reinforce the stream banks, provide shade for temperature attenuation, and contribute to food and nutrient drop.

Off-channel habitat complexes are also important components of watershed restoration. Productivity is extremely high compared to the main stem. These areas provide fish a refuge during extreme flow conditions (both high and low) and also offer a stable area for the fish while the main stem is recovering. ▲

Getting On With Restoring Riparian Stands

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Riparian stands are needing help, whether on the Coast or in the Interior. When beginning the work of restoring these stands, it is important to know what can be done and what to look for. Only a few riparian restoration projects have been initiated in the Interior, but these all have a common problem – inadequate conifer stocking. Some riparian restoration activities that have been successfully used in coastal stands have application in the Interior, and this presentation reviews some such techniques being applied at several interior sites. For example, we can reduce competition through brushing and increase conifer stocking by planting. In addition, where conifers are at extreme risk to frost, insects and disease, we have tried introducing cottonwood to help get conifer seedlings off to a good start. This method appears to be an excellent mid-term solution to inadequate conifer stocking. ▲

Roads and Riparian Restoration

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Historically, riparian environments have been used for logging, mining access, grazing, or recreation. These uses have entailed the construction of numerous roads in, through, or near riparian areas, causing serious, negative impacts on these environments. For example, roads in the riparian environment may drain the water table in a meadow, alter the natural vegetation, segment wildlife, restrict floodplain access, channel stream flows, and increase sedimentation loading.

The Forest Service has implemented new techniques in an effort to make roads more "invisible" to the riparian environment. Techniques range in cost from multi-million dollar segmental bridges with minimal abutments that allow the riparian ecosystem to function naturally, including unrestricted floodplain use; to two hundred dollar culvert elbows placed at the inlet of a culvert that allow previously channeled water to percolate into the ground. Other techniques include permeable road fills that allow the water to maintain more of its natural "sheet flow" characteristics; "culvert arrays," a series of culverts that mimic a more natural flow; and culvert inlet check dams that keep water in the meadow area longer.

An interdisciplinary, interagency team of professionals has been assembled to take these past innovative efforts and develop more new techniques. Our aim is to advance our best management practices so as to restore riparian environments as properly functioning systems. ▲

Fish Habitat Rehabilitation

Barriere River Off-Channel Habitat Development

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Habitat assessments conducted in the Barriere River watershed have indicated that while some logging-related impacts are present, they are relatively small and dispersed, and in general do not provide sites for cost-effective stream restoration. Therefore, ARC Environmental Ltd., under contract to Tolko Industries Ltd., Louis Creek Division, undertook a watershed-scale survey to identify meaningful stream restoration options. While not directly related to individual site impacts, these would serve to provide increased fish habitat capacity to mitigate cumulative resource-related impacts.

An aerial reconnaissance conducted in 1998 identified several restoration opportunities, including a 550 m long relic side-channel of the Barriere River, located 20 km east of Barriere, B.C. Ground-truthing revealed that the site has year-round flow, a suitable gradient, and protection from flooding of the main river. Utilization of the existing side-channel habitat by several species of salmonids, including the North Thompson coho, was limited by lack of access and insufficient water depth.

In September 1999, Summit Environmental Consultants Ltd. conducted a geomorphic and engineering assessment of the project site. A total station survey established benchmarks for future water level measurements, construction, and surveys. Following discussions with federal and provincial agency staff, a construction plan was developed. Budget limitations required a phased approach to channel construction, with Phase 1 construction (the upper 250 m of the channel) being completed during November and December 1999 by local contractors and the North Thompson Indian Band. A physical and biological monitoring program was developed in conjunction with the band, which continued to monitor the site through winter 1999/2000. Biological results to date are encouraging, as coho juveniles have moved into the newly excavated channel.

Development of the lower portion of the channel is slated for 2000. When the project is complete, the channel will include approximately 550 m of improved habitat, including several deep over-wintering pools, floating cover, large woody debris and level control structures. A major design challenge in year 2000 will be to establish and maintain a stable connection to the Barriere River at the channel outlet. ▲

Channel Stabilization on Three Interior Creeks

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Whether related to human activities, natural processes, or both, destabilized stream channels represent an on-going, long-term management problem in many areas of British Columbia. Channel instability often leads to property damage, degraded fish habitat, and impaired water quality. Traditional "hard" engineering solutions for streambank stabilization and channel control are increasingly giving way to "softer" methods that combine engineering approaches with considerations for fish habitat as well as for aesthetics. In addition, limited financial resources for stream restoration projects require simple, cost-effective methods that minimize capital investment, avoid rigorous design, and provide stabilization to the maximum length of channel for available budgets. Several case studies are presented here with examples of channel stabilization and streambank protection on relatively small streams in the interior of B.C. The results of these case studies should be considered preliminary, as the installations have not been subjected to design flow conditions. Only with time will we be able to assess the long-term effectiveness of these structures and techniques.

Sinmax Creek is an S2 (5-20 m wide, fish bearing) stream draining approximately 195 km^2 of forested and cultivated land into Skwaam Bay on Adams Lake in the interior of B.C. Anecdotal accounts and DFO surveys indicate that anadromous fish numbers and length of stream utilized by some fish species have been in decline since the mid-1960s. In recent years, extensive bank erosion, aggradation and channel widening in the lower mainstem have led to property losses and impaired fish habitat. Since 1998, rehabilitation works have been undertaken at six work sites, identified as critical, in the lower two kilometres of the stream. Works to date have focused on bank stabilization and sediment control, including the installation of rock toe key revetments, bar stabilizers, rock spurs, and a constructed riffle. At all six sites, large woody debris and brush layering have been incorporated into both instream structures and reconstructed banks to encourage riparian vegetative growth and provide instream roughness elements. Future plans in the watershed include extensive riparian planting adjacent to the mainstem and instream channel complexing for improved fish habitat capacity.

In 1995, during the construction and servicing of a subdivision on the south shore of Shuswap Lake near Eagle Bay, a contractor undertook to "improve" natural drainage in the vicinity of the development. He constructed a network of drainage ditches to intercept surface flows and transport them efficiently down to a 600 mm culvert crossing on Eagle Bay Road. This action also unintentionally diverted some near-surface flows. Prior to these modifications to the site's drainage, flow through the culvert was rare and no natural watercourse existed above or below the road. After construction, considerable flows of water and sediment occurred in both the collection ditches and the culvert, especially following rainfall events. Sediment accumulations up to 40 cm in depth appeared on private land below the culvert. This killed trees, spread onto an increasing area, and created a braided alluvial fan. In 1998, a small meandering channel was machine-excavated over a distance of three hundred metres between the Eagle Bay Road culvert and Shuswap Lake to assist in the establishment of a single thread watercourse. Live bank protection (wattle fences) and notched log weirs were incorporated into the channel to assist with stabilization and revegetation of the channel banks. A 1.5 m waterfall was constructed near the lower end of the channel.

Gollen Creek is an S3 (1.5-5 m wide, fish bearing) stream that drains mostly forested land into the upper Adams River. The creek's connection to Adams River is via a network of wetlands which appears to limit use of the creek to resident rainbow trout populations. In the spring of 1999, high water and landslides in the upper Gollen Creek watershed caused extensive sediment deposition in the vicinity of the Adams Lake F.S.R. crossing of Gollen Creek. This severely reduced the capacity of a 1600 mm culvert, and completely filled the downstream channel. Although road deactivation works have been completed in the upper watershed, sediment problems in the lower reaches are likely to persist for several years. In order to at least temporarily restore culvert function and prevent over-topping and washing of the road and sub-grade, 200 m of uniform grade channel was constructed downstream of the F.S.R. crossing through the accumulated sediments. The intent of the channel reconstruction was to reduce local deposition by providing a stable channel consistent with upstream and downstream reach gradients. and to allow for continuous transport of sediments. The channel was stepped with upstream log "V" weirs to dissipate stream energy and reduce scour through the remaining fluvial deposits. Live bank protection and brush layering of banks along the channel is planned for the spring of 2000. ▲

Large Woody Debris Anchoring System for Sites With Limited Access

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This presentation describes an anchoring system for Large Woody Debris (LWD) used on the banks of the Little Slocan River in the West Kootenays. Because of the lack of site access for materials and equipment, conventional LWD anchoring with boulders and cables was not feasible here. Instead, we anchored the LWD against flotation and horizontal sliding caused by flowing river water, using MantaRay™ soil anchors, usually used for retaining walls, powerline guy wires, and marine anchorage.

We carried out hydrological and hydraulic studies to determine flows, water depths and water velocities to be used for design of the anchoring system. For the catchment area of the Little Slocan River at the site, 178 km^2, the estimated instantaneous discharges were 160m ^{3}/s, for an average annual flood, and 218m ^{3}/s, for a 10-year return period flood. Using river cross-sections provided by MELP together with these design floods, we estimated that the Little Slocan River water levels would rise at least 1.5 to 2.5 m in the reach where the site is located, fully submerging the LWD. Due to the location of the LWD on the outside of a bend, we estimated that corresponding water velocities would be in the range of 2 to 3 m/s.

Using the Watershed Restoration Management Report No. 8, "Large Woody Debris Fish Habitat Structure Performance and Ballasting Requirements" (S. D'Aoust and R. Millar), we determined that 6,000 to 11,000 kilograms of ballast was required to anchor each piece of LWD (with rootwads attached). This ballasting has traditionally been provided by the cabling of boulders to the LWD. In this case, for each piece of LWD, two to three boulders, each with a diameter of 1.3 m, would have been required. Due to limited site access, it was not possible to import the required boulders (approximately 100 boulders to anchor thirty to forty pieces of LWD), and no boulders were available at site.

The solution was to use MantaRay™ soil anchors and cable to anchor the LWD. The anchors were driven approximately 4 m into the ground using a portable, hydraulic jack. The anchors were load-tested, then cabled to the LWD. The supplier, Dywidag Systems, provided an experienced technician to work with the field crew throughout the installation process. The thirty logs that were anchored remained in place through the 1999 freshet. Because of the large snowpack, the 1999 freshet could have been an extreme event, but due to a long, cool spring, the resulting peak flows were late and in the order of 10-year return period flows or less. The anchored LWD remained in place. ▲

Rehabilitation of Upslope Disturbed Sites

A New Proactive Risk-based Procedure for Managing Impacts from Forest Development Related Landslides on Identified Downstream Resources

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This project developed and implemented an innovative, risk-based procedure that is able to manage the potential for landslides that may start from existing roads and trails and descend to downslope streams and resources. The procedure is based on the principle that it is many times more cost-effective to achieve stable channels and cleaner water through the prevention of impacts to streams than through post-landslide restoration efforts.

The study area encompassed approximately 250 km of existing forest roads on the west side of the Hunters Range above the lower Shuswap River and Mara Lake. These were investigated to determine risk to streams from potential road failure and road drainage related landslides. An office review identified hazards based on road configuration and proximity to Terrain Stability Hazard Class IV and V terrain. Consequence was defined from the potential impacts to domestic water supply, fish habitat, life and private property, utilities, and highways. This initial office exercise was used to prioritize potential high-risk sites for detailed field assessments that would refine hazard and consequence ratings. This process resulted in the focus of professional field assessments only at those sites where there was a potential problem that could have significant negative consequences. The field assessments further prioritized and delineated hazard and consequence to provide a qualitative risk rating, and recommendations for hazard mitigation works.

The office review identified 218 sites as potentially high or very high hazard. Further office assessment of the downslope and downstream consequences determined that 130 of these sites were potentially high or very high risk, and thus a priority for professional field assessment. Of these 130 sites, 30 were confirmed after field assessment to be high risk, 20 moderate risk and the rest low risk. The high-risk sites were further stratified into high or very high short-term risk (13 and 6 sites respectively) and high or very high long-term risk (9 and 2 sites respectively).

This stratification of risk allowed managers to make proactive informed decisions as to the allocation of limited financial resources for road maintenance, upgrading or deactivation specifically targeted to prevent downstream impacts. The methodology proved to be very effective in the “flat-over-steep” terrain of the Interior Plateau, in an area with terrain mapping as the risk assessment starting point. ▲

Lessons Learned in Steep Slope Road Deactivation

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In 1996, a site for road deactivation was identified as a priority in an Integrated Watershed Restoration Plan completed for the Barriere River Watershed. The following year a road deactivation prescription was prepared and implemented, and additional mitigative activities were completed in 1999.

Difficulties encountered at the site were primarily associated with Slide B. This slide was activated after the initial road construction; it continued to transport sediment, post-deactivation. The downstream resources affected by the slide included an S2 (5.20 m wide, fish-bearing) creek with a bull trout population. There were difficulties with the re-established natural drainage patterns and with maintaining access requirements; in addition we had concerns with safety for the excavator operator who reduced fillslope pullback. In hindsight, we concluded that the prescription was correct, but some minor adjustments could have been made during implementation.

Slide B had some minor instability after the completion of deactivation. The major problem, however, was associated with the lack of vegetation, rill erosion and the transport of sediment that continued to occur.

Additional efforts focused on how to reduce the risk to downstream resources. We considered mitigation options that included bio-engineering (bio-technical remediation), dry blasting, further pullback at the source of sediment, and constructing sediment retention structures (dams).

The best opportunity for success was determined to be the construction of sediment retention structures. As they were built on the alluvial fan upstream of the key resource to be protected (bull trout), they are easily accessible for maintenance. The ultimate cost of designing and constructing the structures was $34,000.

Lessons Learned

1. Evaluate where the values are: if correcting at problem a source is not feasible, focus on mitigation activities where the values can still be protected.
2. Ensure that the operator only hears one voice during a project.
3. Spreading seed manually rather than by helicopter would not have been dependent on weather, and costs would have been reduced.
4. Where surface erosion could be a problem, remove as much loose material as safety permits.
5. Be careful when re-establishing natural drainage patterns and be sure to remove any loose fill materials where the water is going to run.
6. Don't set unrealistic goals for post-deactivation access.
7. Continue with a re-vegetation program. In difficult areas, implement an annual program with small test sites to see what works. ▲

The Berry Messiter FSR: A Challenging Upgrade To A Piece of Our Past

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The Berry Messiter Forest Service Road is just one of many "back-country" roads in routine use across the province. Unlike many, though, the Berry Messiter has a past that can sometimes come forward to haunt the present. In this case, parts of the roadway contained significant fills supported by old timber cribs, some of which may have been installed when this road was part of the "original" route of the North Thompson (Yellowhead) Highway. The main concern was that the crib walls were at the end of their service life, and had to be replaced in some manner. In this part of the North Thompson valley, the CN Rail mainline is located just a short distance downslope from the road. To further complicate matters at the site, the existing road corridor is located on a steep, bedrock-controlled hillside.

The location of the site imposed several challenging constraints on formation of an appropriate work plan for road upgrading. Firstly, as the existing cut slopes were already fairly high at parts of the site, one of the requirements was that the conceptual design should minimize excavation volumes. A second consideration was to minimize the height and extent of any replacement retaining wall structures needed to support the roadway. A third and key requirement was to determine whether any alternatives to blasting were feasible, as any blasting activity next to a rail corridor must be conducted in short/infrequent "work windows" between trains.

To overcome these constraints, a work plan and prescriptions were developed which relied on mechanical breakage of the rock with a large hydraulic hammer, and lowering of the road grade rather than movement of the road alignment into the slope. This methodology had the effect of providing added width for the road and ditchline, with only a few short sections of low lock-block walls required. In summary, the development of an upgrading strategy that included selection of the appropriate methods and equipment, contractor and operators, played a very large part in the successful completion of this challenging project. ▲

The Willis Creek Project: Connecting Restoration Works from Upslope to Stream

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With funding from Forest Renewal BC, Weyerhaeuser Canada Ltd. has coordinated a multi-year restorative effort in a portion of the Willis Creek basin, south of Princeton, B.C. Work has been carried out to rehabilitate eight landslides and six sediment sources, all of which formerly had a direct impact on Willis Creek.

The Willis Creek project is a good example of the connection of restoration objectives from upslope areas to streams. At the initial stage of the project, an overview assessment was carried out. This characterized the site, set goals and priorities, and established the framework for the detailed prescriptions and restorative works to follow. In this case, work commenced in the upland plateau and upper hillslope areas. The aim was to improve surface water management in areas associated with relatively large openings resulting from pest-control-directed harvesting. In subsequent stages, improvements were made to the existing mainline road. In addition, a segment of an old "valley bottom" road on which the most persistent landslides were occurring, was permanently deactivated. Most recently, site restoration has focused on stream habitat enhancement and stabilization of the channel banks in the areas of greatest disturbance.

This overview of the project describes the results we achieved, highlights the range of methods and techniques we used, and offers some insight into the practical aspects of site restoration work that we learned along the way. ▲

The McKinley Creek Slide: A Phased Stabilization

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The McKinley Creek WRP slide stabilization project had several key components that led to the success of the stabilization works. Close monitoring was done to help understand the physical constraints of the slide, and to evaluate and/or modify the remedial works. Proactive discussions with various referral agencies allowed suitable strategies to be developed and evaluated. Access to information and on-the-job training gave excellent completion results for the stabilization works.

The site is located approximately 40 km east of the community of Horsefly, in the Horsefly Forest District, Cariboo Forest Region. The slide is just outside the edge of a cut block boundary, defining a break in slope between moderate in-block terrain and steeper slopes leading down to the riparian zone of a high value fish stream. A combined 1000 m^3 of debris had accumulated in the gentle slopes of the riparian area over the past four or five years. The slide debris was estimated to accumulate annually at a rate of about 10 to 25% of the combined total volume. The slide was brought to the attention of the Weldwood of Canada Forest Renewal BC WRP program in fall of 1997.

During the next year (1998), Weldwood and consultants discussed several options to stabilize the slide site with input from various referral agencies including Forest Renewal BC, MoF, DFO, and MELP. Phase I stabilization works were done in the fall of 1998 and consisted of subsurface flow control above the head-scarp and transport zone stabilization. Phase I works cost $33,277. The results of these works were monitored by Weldwood during the winter/spring of 1999.

Phase II objectives for further reducing potential sediment delivery to McKinley Creek were defined in May of 1999. Blasting was done to remove and terrace overhanging steep portions of the head wall. Bio-technical slope stabilization was done using willow collected and stored the previous winter. A team of local workers were trained on the job. Over the first growing season the willow had good growth and low mortality. Phase II works cost $16,923. The total cost to date for stabilization measures has been $50,200. Monitoring and maintenance is continuing at this site. ▲

Seller Creek Sedimentation Study

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A detailed study of the sediment delivery potential, with respect to soil erosion and potential mass wasting, was completed in the lower reaches of Seller Creek in the Cariboo Forest Region. Seller Creek is a tributary to the Cariboo River, with the confluence located approximately 6 km downstream from Cariboo Lake.

The lower Seller Creek drainage is a geomorphically active area with respect to landslide activity. Large-scale debris slumps and debris slides are thought to have occurred since the last period of glaciation. The air photo history for this area shows evidence of these debris slumps before any logging development in the area.

A total of nineteen landslides were identified in the field during this study. Eight of these landslides are considered naturally occurring, while the remaining eleven are thought to have been influenced by the logging activities in the area. Historically, the natural landslides have been occurring in the lower reaches of Seller Creek. These landslides have varying levels of stability and revegetation. An estimated 99% of the total volume of sediment delivered by these landslides was derived from the naturally occurring events.

The sediment delivery potential with respect to surface erosion was assessed on these landslides and four had a high potential, one had a moderate potential, and the remaining six had a low potential. The sediment delivery potential, with respect to future mass wasting, was assessed: six had a high potential, two had a moderate potential and the remaining three had a low potential. Assumptions on the downstream consequence to the fishery resource were made, due to concerns with "actual" impacts to this resource and the history of large scale, natural instabilities in this area. From this it was determined that seven events had a moderate to very high risk with respect to the downstream fishery values and these hazards.

Priorities for additional work to be completed and rehabilitation strategies were developed: these were based on the reduction in risk and the cost-effectiveness.

Planning and Monitoring

Protection vs. Restoration: Copying Nature and Correct Techniques

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The following notes from this presentation of Mr. Isaacson's perspective on protection vs. restoration were transcribed by Donna Underhill.

In Idaho, restoration work began in the late 1960's, as did monitoring of sediment and flow. The restoration work began, in part, as a response to two 1-in-200 year flood events that occurred in 1964 and 1965. At this time the restoration involved cleaning up the area, removing all the wood, and trying to put the stream back where it belonged. These restoration projects were large and engineered. In 1974 there was a large rain-on-snow event that resulted in $22 million of restoration. It was a turning point in restoration planning. People began to realize that, prior to restoration, the stream hydraulics should be studied and the system treated as a whole, including the forests and roads within the watershed. The Clean Water Act was passed, and at this time protection became a key part of planning in development projects. Restoration work began to put wood and boulders back into streams. Then in the 1980's forestry harvesting was accelerated, and restoration work declined. 1990's brought a halting of new road construction, the Endangered Species Act now protects species such as bull trout, trees are salvaged, etc. Looking back after many hundreds and thousands of dollars have been spent on restoration, are we any further ahead? Often, those sites that were not restored are better off than those that were restored. A graduate student can still receive a PhD in fisheries without a course in fluvial processes. We should be paying attention in our design to the stream width and gradient; we need to design according to meander pattern and width/depth ratio. We tend to overbuild, which encourages deposition. We need to remember that restoration is more an art than a science. Mr. Isaacson advised using stream typing (Rosgen) and identifying the proper type of restoration for each reach type.

Willow Watershed Effectiveness Monitoring: Did it Work?

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The Willow Watershed WRP Effectiveness Evaluation is completing its third year.

The goals of the Willow Effectiveness Monitoring Strategy (EMS) are:

- To optimize WRP work in its enhancement of environmental values and cost efficiency,
- To alert managers to sites where work has failed and needs repair,
- To identify the success of treatments in addressing watershed level objectives.

Routine evaluation has provided initial results on the success of instream and hillslope works. Results are initial because most sites have not been through a post-work snowmelt freshet. Work done in the Willow Watershed in 1998-99 includes installation of cross-ditches to reduce surface erosion and to address peak flow, installation of log spur and riffle structures to increase pool frequency and depth in streams, and soil bioengineering and pullback to reduce slope instability. Most of these treatments had initial success, with some exceptions. For example, some cross-ditches installed in fine materials during wet conditions required repair. In addition, some cross-ditches were installed too far apart to return water intercepted by road cutslopes back into groundwater.

Success of WRP activities was evaluated at each site through 1) the identification of the site-objective, 2) the selection of monitoring variables that directly measure the impact of the treatment on the site-objective, 3) the measurement of monitoring variables before and after work, and 4) the evaluation of success through comparison of pre- and post-work monitoring, and through comparison with any available bio-indicators.

Success at the site scale was related to the watershed scale through hierarchies of objectives that connect the site-level objectives to the watershed-level objective, and also by placing the evaluated sites into context with those treated but not evaluated, and with those not yet treated.

Outputs for adaptive management have been provided. These include a list of areas where things could have been done better, with recommendations for improvement.