Therriault Creek Riparian Revegetation 2010 Monitoring, Maintenance and Phase III Implementation Report

Contract #110032

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Table of Contents

Introduction

This report describes work completed in 2010 at the Therriault Creek restoration site under Fish, Wildlife and Parks Contract #110032. A total of three tasks were included in contract #110032:

- Task 1. Conduct 2010 Effectiveness Monitoring and Reporting
- Task 2. Determine Maintenance Needs and Implement 2010 Maintenance
- Task 3. Implement Phase III Revegetation Treatments

Task 1 included gathering data from a limited number of established monitoring plots and recording general observations about site conditions and trends. Maintenance needs and Phase III revegetation treatments were also finalized under Task 1. Field work for Task 1 was completed in August 2010.

Task 2 included identifying and implementing maintenance needs for the Phase I (2007) and Phase II (2009) revegetation treatments. Maintenance tasks included watering, re-securing browse protectors, re-securing solarization fabric and soil lift stakes, and pulling weeds from vegetated soil lifts. Maintenance tasks were completed during July and August 2010.

Task 3 included installing the Phase III revegetation treatments. These treatments were based on monitoring completed during 2008 and 2009 and observations made in 2010 under Task 1. The *Therriault Creek Riparian Revegetation Monitoring Report* (Geum Environmental Consulting, Inc. 2009) provides details on the adaptive management process for determining Phase III treatments. Phase III revegetation treatments were completed during October 2010 and included:

- Protection of 154 existing residual planted riparian shrubs;
- Planting of 1,100 riparian shrubs and trees;
- Removal of solarization fabric at Temporary Solarization Site 1 and seeding exposed soil with a diverse native seed mix;
- Installation of 1,580 square feet of planted solarization treatment;
- Two herbicide applications targeting Canada thistle (*Cirsium arvense),* yellow toadflax (*Linaria vulgaris*), and reed canarygrass (*Phalaris arundinacea*), and sulphur cinquefoil (*Potentilla recta*); and
- Evaluation and re-location of riparian fencing installed at the site.

Work completed in 2010 represents the third phase of revegetation at the Therriault Creek project site. As described in previous reports, successfully converting the riparian vegetation along Therriault Creek within the project reach to a mosaic of native riparian shrubs and trees requires a multi-year phased approach. The intention of the initial phase, completed in fall 2007, was to implement a range of treatments based on a detailed evaluation of existing site conditions and ecological processes driving vegetation succession at the site. The results of 2008 and 2009 effectiveness monitoring were used to determine maintenance needs for 2007 treatments and identified some additional revegetation treatments which were implemented in September and October 2009 (Phase II). This report describes the results of 2010 effectiveness monitoring, maintenance

activities completed in 2010, locations and quantities of revegetation treatments implemented in 2010 based on the results of effectiveness monitoring and provides recommendations for continued monitoring and maintenance at the site.

2010 Effectiveness Monitoring

This section describes the results of effectiveness monitoring completed in August 2010. Phase III (2010) revegetation treatments were determined based on evaluating the results of 2008, 2009, and 2010 effectiveness monitoring using an adaptive management framework. Details on the Therriault Creek riparian revegetation project including: previously installed revegetation strategies and treatments; effectiveness monitoring methods and 2008 and 2009 results; and the adaptive management framework can be found in four separate documents. These documents are: *Therriault Creek Riparian Revegetation Plan* (Revegetation Plan) prepared for Kootenai River Network (Geum Environmental Consulting, Inc. 2007a); *Therriault Creek Riparian Revegetation Plan Implementation Report* (2007 Implementation Report) prepared for Montana Fish, Wildlife and Parks (Geum Environmental Consulting Inc. 2007b); *Therriault Creek Riparian Revegetation 2008 Monitoring Report* prepared for Kootenai River Network (2008 Monitoring Report) (Geum Environmental Consulting, Inc. 2008); and *Therriault Creek Riparian Revegetation Maintenance and Monitoring 2009 Report* (2009 Monitoring Report) prepared for the Kootenai River Network (Geum Environmental Consulting, Inc. 2009).

As described in the monitoring reports, three types of monitoring are necessary components of the integrated monitoring and adaptive management program. These include: baseline, as-built, and effectiveness monitoring. ***Baseline monitoring*** documents the pre-restoration condition and is described in the Revegetation Plan prepared for the project. ***As-built monitoring*** documents completed treatments and for the treatments implemented in fall 2007, is provided in the 2007 Implementation Report. ***Effectiveness monitoring*** addresses whether project objectives are being met, determines maintenance needs, and provides inputs into decision pathways for adaptive management. The results of 2008 effectiveness monitoring are provided in the 2008 Monitoring Report. The 2009 report provides the results of 2009 effectiveness monitoring for treatments implemented in 2007, compares those results with 2008 effectiveness monitoring results and describes results of as-built monitoring for revegetation treatments implemented in September and October 2009. This report provides the results of 2010 effectiveness monitoring, compares those results to previous year's monitoring and how results were used to determine 2010 maintenance needs and Phase III revegetation treatments. This report also provides the as-built monitoring for Phase III revegetation treatments.

In 2010, effectiveness monitoring data were collected for a select number of revegetation treatments implemented during Phase 1 (2007) and Phase II (2009) of the riparian revegetation project (Figures 1 and 2). The focus of 2010 effectiveness monitoring was to verify trends in treatment effectiveness that had been observed in 2008 and 2009 in order to confirm maintenance needs and Phase III treatment recommendations. Effectiveness monitoring completed in 2010 included:

- Recording general observations for all revegetation treatments;

- Taking photographs of all revegetation treatments;
- Collecting survival monitoring data for two containerized planting units;
- Collecting survival monitoring data for two planted solarization plots;
- Evaluating the need for browse control on vegetated soil lifts and coir logs;
- Evaluating revegetation treatment maintenance needs; and
- Evaluating the riparian fence location and re-alignment options.

2010 Effectiveness Monitoring Results and Discussion

This section provides a summary of the results of 2010 effectiveness monitoring. As an overview, Table 1 provides a brief description of each revegetation treatment installed at the project site, the purpose of the treatment, results of 2010 monitoring, and adaptive management recommendations made based on monitoring, including Phase III revegetation treatment recommendations. The following sections discuss the results of 2010 monitoring, compare those results with 2008 and 2009 effectiveness monitoring results and discuss how 2010 revegetation treatments and maintenance needs were determined.

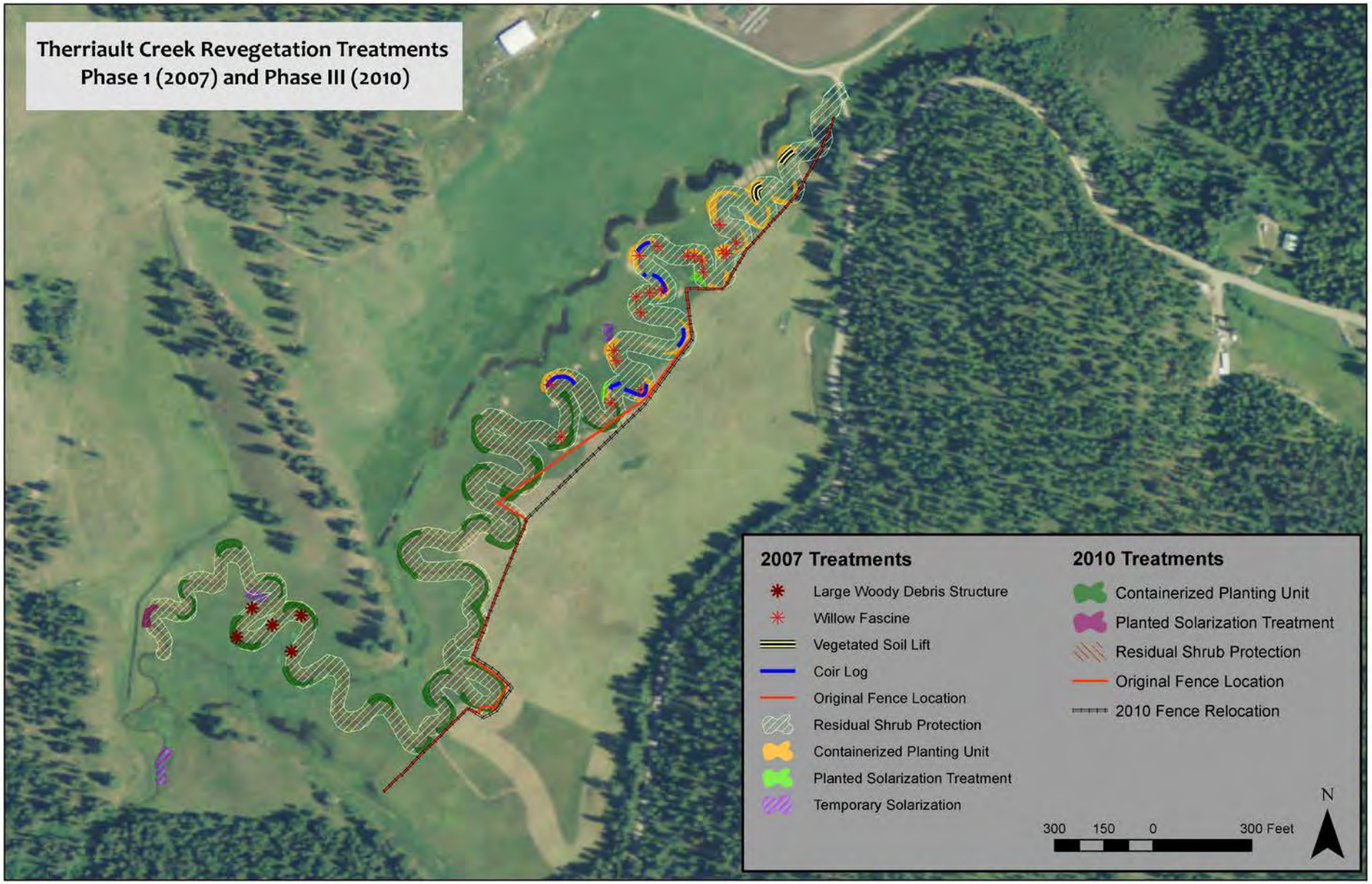


Figure 1. Overview figure showing riparian revegetation treatments installed in 2007 and 2010 at the Therriault Creek Riparian Revegetation project site.

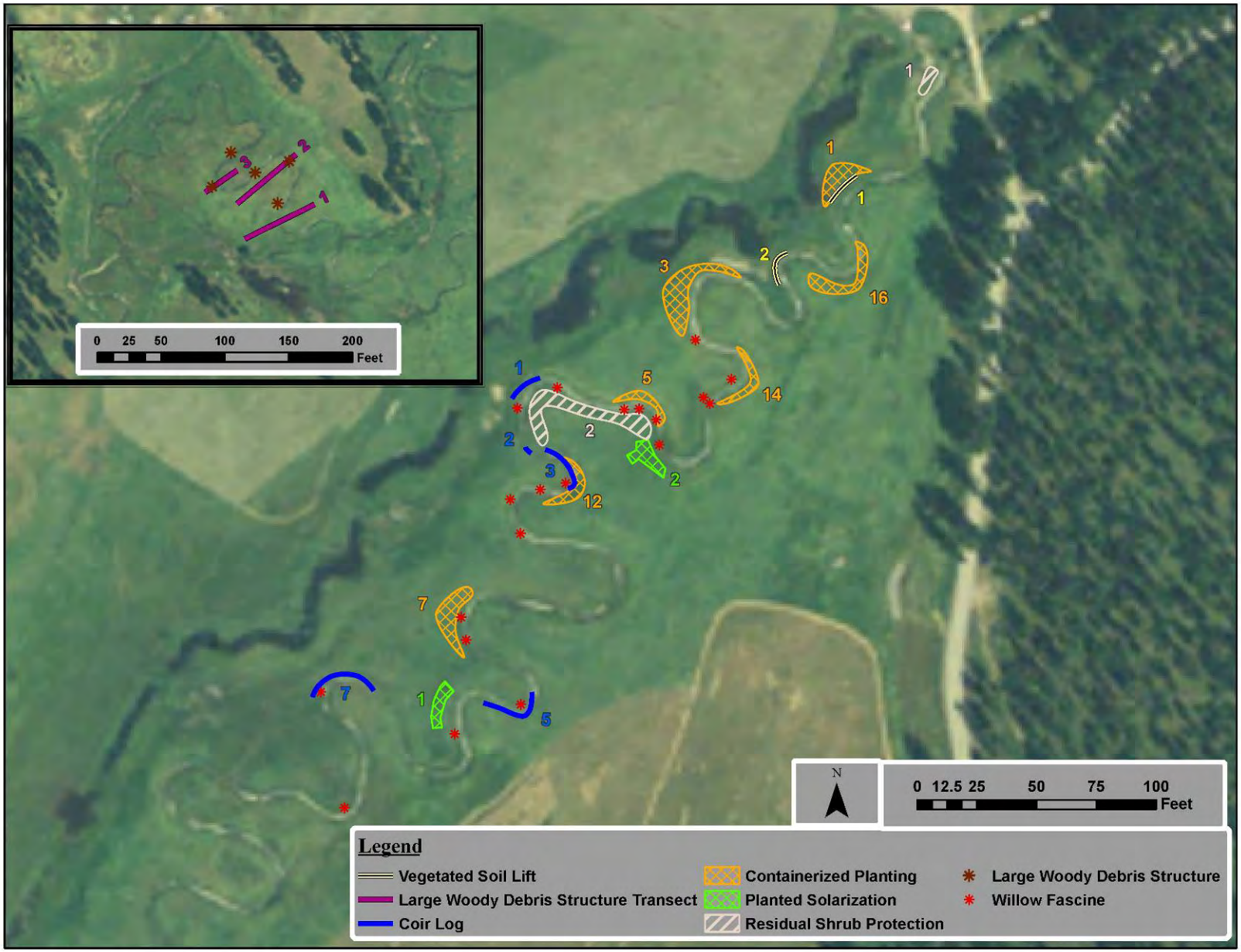


Figure 2. Effectiveness monitoring overview figure showing the locations of treatments monitored in 2008 and 2009. In 2010, survival data was collected at Planting Units 1 and 7 and Planted Solarization Plots 1 and 2.

Table 1. Description of riparian revegetation treatments installed at the project site, observations made during 2010 effectiveness monitoring and a summary of adaptive management recommendations based on effectiveness monitoring.

Treatment	Treatment Description/Purpose	2010 Effectiveness Monitoring Observations	Adaptive Management Recommendations Based on Monitoring	2010 Photograph
Residual Shrub Protection	Woody vegetation establishment technique consisting of placing four foot tall rigid plastic mesh browse protectors and three foot by three foot brush blankets around surviving shrubs and trees planted during channel construction (2005). This treatment aims to protect previously installed plant material from browse and reduce competition from aggressive pasture grasses.	Residual shrubs protected in 2007 and 2009 continue to thrive compared to unprotected residual shrubs which remain stunted and browsed. Due to the larger sized protectors installed in 2009, minimal re-securing and straightening was required during 2010 maintenance.	Repair and re-secure any damaged protectors in summer 2010. Protect remaining residual shrubs in the project reach during Phase III.	
Containerized Planting	Technique for establishing native trees and shrubs along the channel to provide stability and habitat, and create long term seed sources. Treatment consists of installing one and two gallon native shrubs and trees in select areas along the restored channel. Treatment includes placing four foot tall rigid plastic mesh browse protectors, three foot by three foot brush blankets and six to eight inch rigid plastic vole protectors around each plant.	Survival of containerized plants remains high, but many plants have been hedged by browsing to the top of the installed browse protectors. Many of the plants have also filled out even the expanded protectors.	Water plants in summer 2010. Plant additional shrubs and trees in lower portions of the project reach. Protect shrubs with mulch mats, browse protectors and vole protectors. Use larger diameter browse protectors than Phase 1. Use shredded mulch inside vole protectors. Expand or remove browse protection on shrubs that have filled the capacity of the protectors in 2010 or 2011.	

Treatment	Treatment Description/Purpose	2010 Effectiveness Monitoring Observations	Adaptive Management Recommendations Based on Monitoring	2010 Photograph
Solarization	Weed control technique used to reduce the cover of aggressive pasture grasses and weeds such as reed canarygrass and create conditions to allow establishment of native trees and shrubs in areas otherwise dominated by undesirable species. Treatment consists of installing woven black fabric in target areas to heat kill live plants and seed. Treatment includes both temporary (non-planted) and long term (planted with native woody vegetation) plots.	Solarization has effectively killed undesirable species in Plot 3 and seeding of native species appears to be successful. Some undesirable species are re-colonizing seeded plots. Overall survival in long-term plots remains high. Some species planted, such as alder and aspen continue to show accelerated growth. Other species show lower survival compared with non-solarized plots. Some have died back but are re-sprouting at the base.	Remove fabric at Temporary Solarization Plot 1 and seed with native species mix. Continue to evaluate Temporary Solarization Plot 2 for effective kill of undesirable species. Continue to evaluate Plot 3 for cover of seeded native species and colonization by undesirable species. Continue to observe species growth and survival in long-term plots. Re-secure edges and staples in long-term plots and hand-pull weeds around the base of plants. Install additional long-term planted solarization plots during Phase III targeting reed canarygrass areas.	 

Treatment	Treatment Description/Purpose	2010 Effectiveness Monitoring Observations	Adaptive Management Recommendations Based on Monitoring	2010 Photograph
Vegetated Soil Lift	Streambank stabilization and woody vegetation establishment technique that will provide stability on high stress or high risk outer meander bends to encourage the establishment of native woody vegetation that will in turn provide long term natural channel stability. Treatment incorporates layers of coir fabric, soil, and dormant willow cuttings.	Willow survival on soil lifts remains patchy. Where survival is high, cover is dense but height is suppressed by browse.	Hand-pull weeds on soil lifts and re-secure wooden stakes during summer 2010. Due to feasibility issues and uncertain effectiveness, do not install browse control measures at this time. Continue to evaluate effects of browse on continued survival and growth of willow cuttings.	
Willow Fascines	Woody vegetation establishment technique using willow cuttings tied together to form a linear bundle and installed in depositional areas along the channel. Treatment is used for the establishment of native woody vegetation on depositional areas where willows and cottonwoods would naturally recruit, providing roughness to capture floating seed, debris, and fine sediments.	Willow fascines have trapped sediment and debris and are functioning to build depositional features within the channel margins and provide substrate for colonizing vegetation.	No maintenance required. Continue to observe treatment for effectiveness.	

Treatment	Treatment Description/Purpose	2010 Effectiveness Monitoring Observations	Adaptive Management Recommendations Based on Monitoring	2010 Photograph
Large Woody Debris Structures	Instream and floodplain habitat enhancement technique using whole trees, logs and other large woody debris to create interlocking debris jams in the channel and extending onto adjacent floodplain surfaces. This treatment aims to enhance habitat, provide roughness features to trap floating organic material and seed and encourage over-bank flooding, retention of flood waters in adjacent floodplains and deposition of fine sediments, creating microsites for woody vegetation to establish.	Wood structures have trapped sediment and debris, created habitat for fish, and prolonged floodplain inundation during high flow events.	No maintenance required. Continue to observe treatment for effectiveness.	
Coir Logs	Streambank woody vegetation establishment technique for the purpose of providing a stable point at the land water interface and beneath the pasture grass sod to create conditions for willows to establish. Coir biodegrades over 5-7 years allowing willow roots to provide natural long-term channel stability. This treatment combines high density coir logs (twelve inch by ten foot coconut fiber bales) and dormant willow cuttings.	Willow growth on coir logs continues to be slow and suppressed by browse. Coir logs remain structurally intact and are supporting naturally colonizing vegetation.	No maintenance required. Continue to evaluate effects of browse on continued survival and growth of willow cuttings.	

Treatment	Treatment Description/Purpose	2010 Effectiveness Monitoring Observations	Adaptive Management Recommendations Based on Monitoring	2010 Photograph
Herbicide Application	Application of herbicide to reduce cover of noxious weeds and other undesirable species, therefore reducing competition with desired grasses, forbs and planted shrubs and trees.	Herbicide applications have been effective at controlling most target species. Canada thistle has been reduced in the upper end of the project reach but densities in the lower portion of the reach have increased. Isolated patches of reed canary grass have also decreased in the upper end of the project area.	Based on the results of 2009 weed mapping, continue to treat target species in the project reach in 2010. Herbicide application, particularly targeting Canada thistle should continue in 2011.	

Residual Shrub Protection

Based on visual observations made in August 2010, it appears that all residual shrubs that have been fitted with browse protectors are alive and have grown both vertically and horizontally. Some plants have grown as much as three feet above the browse protector (Figure 3). Figure 3 shows the growth of some residual shrubs between 2009 and 2010. Figure 4 also shows the growth of protected shrubs and the condition of a residual shrub that was not protected. The amount of growth appears to differ somewhat between species, with willow species showing the most pronounced growth and other species such as dogwood showing less pronounced growth. This treatment has been successful in releasing previously planted shrubs from browse suppression.

Based on the above observations and the results of previous year's monitoring, the following adaptive management recommendations were made:

- Repair and re-secure browse protectors during summer 2010.
- Protect all remaining residual shrubs that can be located within the project reach during summer or fall 2010.

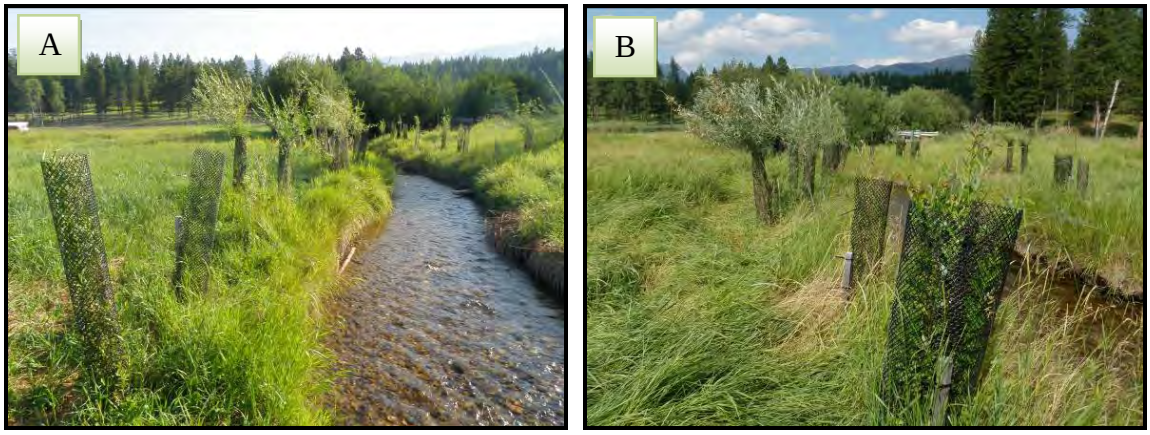


Figure 3. Photographs comparing residual shrubs protected in 2007 in 2009 (A) and 2010 (B). Some protected shrubs, particularly sandbar willows, have grown more than 3 feet above the height of the browse protection. Other protected shrubs, such as those in the foreground of the photographs have shown significant growth but continue to be hedged by browse to the height of the browse protection.

Figure 4. Photograph A shows the continued browse occurring on unprotected residual shrubs and the resulting suppressed growth form. Photograph B shows residual shrubs that have been protected from browse since 2007. The residual shrubs that were protected from browse have grown to the height of the browse protector (four feet) and in some cases have grown to the capacity of the browse protectors, which were expanded in 2009.

Containerized Planting

Two of the sixteen Phase I planting units were selected for repeat survival monitoring data collection in 2010. Only a small number of sites were selected for 2010 monitoring because overall plant survival remained high in 2009 (89% overall). Planting Units 1 and 7 were selected for monitoring because they were at opposite ends of the Phase I project reach and represented the range of survival recorded in 2009. Planting Unit 1 was at the high end with 98 percent survival in 2009 and Planting Unit 7 was in the mid range with 90 percent survival in 2009 (Figures 5 and 6). The results of 2010 survival monitoring are summarized in Table 2. Overall plant survival recorded in 2010 in Planting Unit 1 was 91 percent. Survival in this plot in 2008 was 100 percent. Overall plant survival in 2010 in Planting Unit 7 was 93 percent. Survival in this plot in 2008 was 96 percent. Based on observations of plant survival made during the August 2010 monitoring site visit, overall survival remains high in all planting units. Between 2008 and 2009, three planted species stood out as having reduced survival; alder (*Alnus incana*), birch (*Betula occidentalis*) and spruce (*Picea engelmannii*) (Geum Environmental 2009). Based on 2010 observations, spruce survival continues to decline in most planting units. However, in some planting units a few spruce are surviving and growing. It is unclear if alder and birch survival continues to decline because survival of these species in the two monitored plots did not change between 2009 and 2010. Many of the surviving alder and birch are thriving. Appendix A provides 2008, 2009 and 2010 comparison photographs for monitored planting units.

Figure 5. Photographs compare Planting Unit 7 in 2008 (A) and 2010 (B). Photographs were taken from the downstream end of the plot looking upstream.

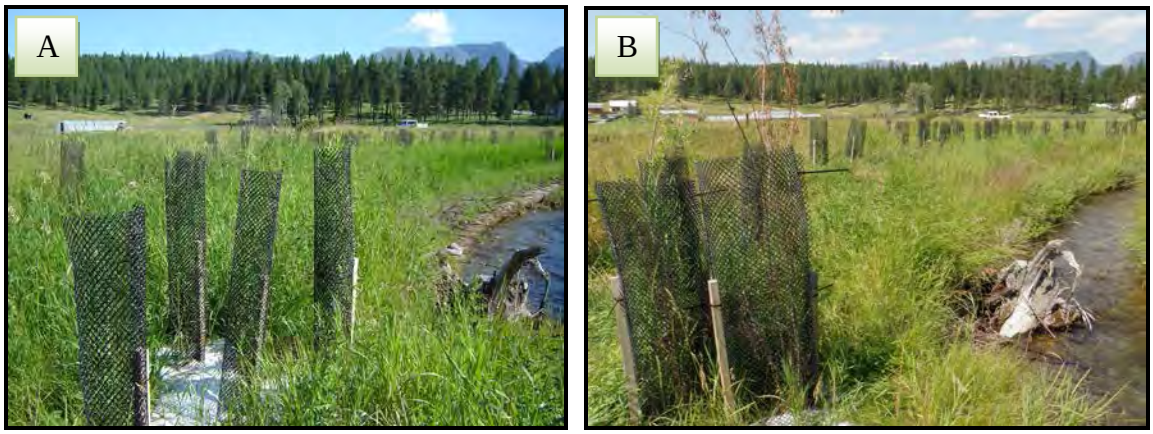


Figure 6. Photographs compare Planting Unit 1 in 2009 (A) and 2010 (B). Photographs were taken from the downstream end of the plot looking upstream.

Pasture grasses remain the dominant understory species in most of the Phase I planting units but general observations of the entire project area suggest that the site is trending towards a wetter native community with higher percent cover of a range of sedge and rush species. There are new patches of sedge dominated communities throughout the planting units as well as in the hay field southeast of the channel (Figure 7). Percent cover and diversity of wetter species appears to have increased compared with observations made in 2009.

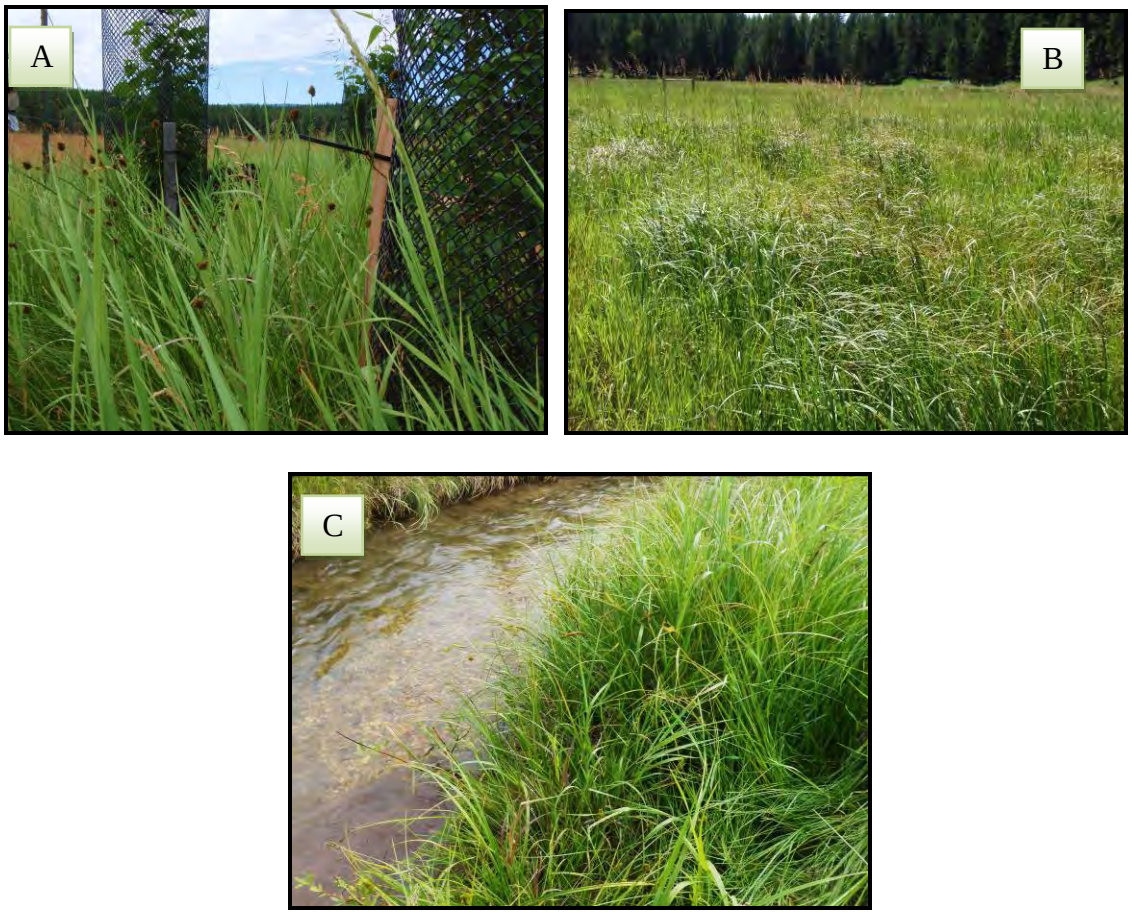


Figure 7. Photographs showing patches of sedge establishing in planting units along the creek (photographs A and C) as well as in the hayfield beyond the creek (Photo B).

No evidence of vole damage to any containerized plants in monitored planting units was observed. Vole protectors continue to be effective in protecting installed plants from girdling or other rodent damage.

In 2009, most of the browse protectors originally installed in 2007 were expanded to provide additional capacity for plant growth. Despite this expansion, many plants had grown to maximum capacity of the expanded protectors by summer 2010. There were sign of elk use throughout the project reach. A number of browse protectors were damaged and many plants suffered severe hedging; defined as, browse of all growth above the height of the browse protector has been eaten (Figure 8). Although this may slow vegetative growth, given the size of the shrubs hedged, it is likely that the root systems of the surviving plants are established enough to withstand moderate browse pressure. The established root system coupled with protection of the lower half of the plant should enable the plant to survive browse pressure and eventually reach a height that is less vulnerable to browse. If heavy browse continues it may affect growth and survival of damaged shrubs.

Based on the above observations, and the results of previous year's monitoring, the following adaptive management recommendations were made:

- Repair and re-secure damaged browse protectors during summer 2010.
- Water all planted shrubs and trees during August 2010.
- Install additional containerized plants in the lower half of the project reach during fall 2010.
- Install mulch mats, vole protectors and browse protectors around all containerized plants.
- Use shredded mulch instead of wood chips in vole protectors to reduce grass growth inside the vole protector.
- Install 16-inch diameter browse protectors to increase the area available to support plant growth.

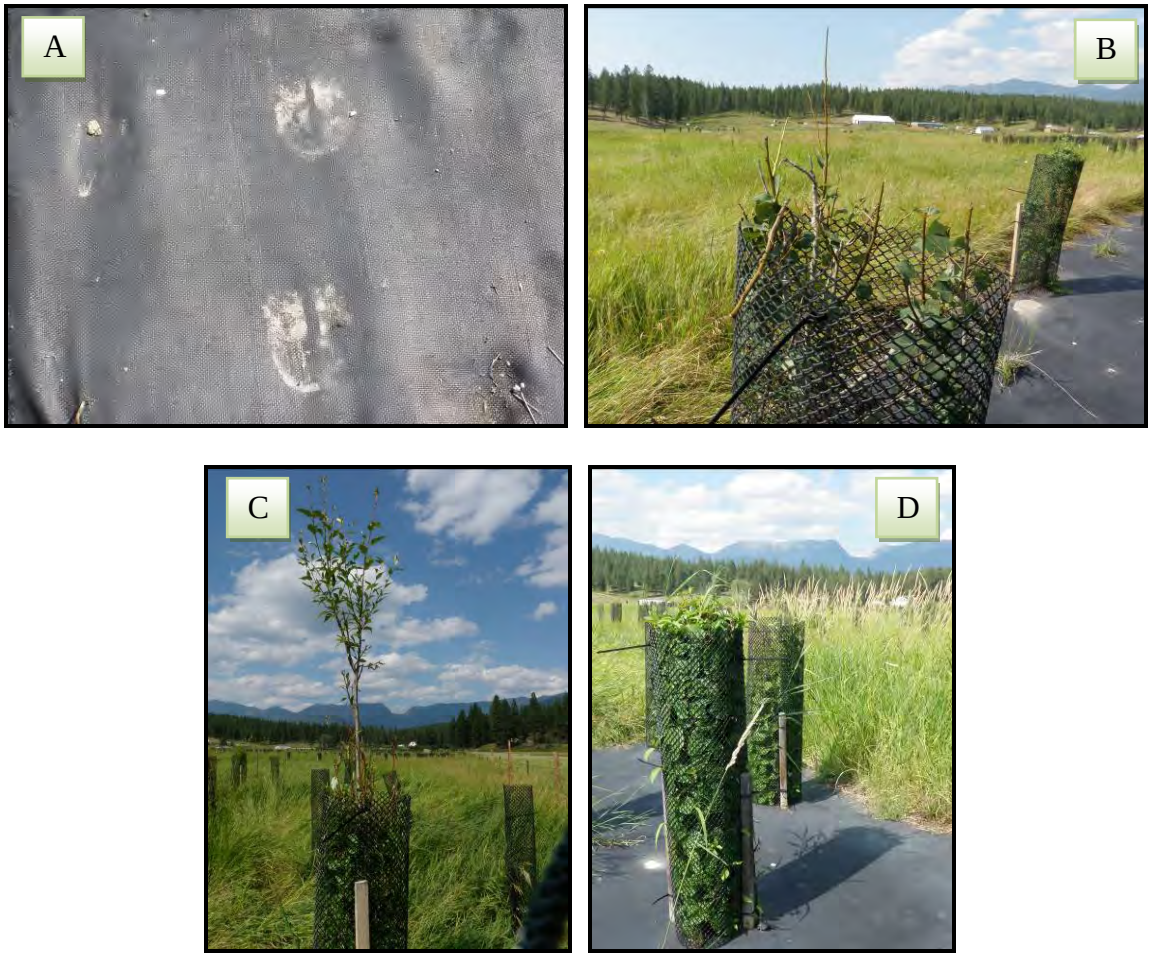


Figure 8. Photographs show evidence of browse by ungulates. Photograph A shows tracks through a planted solarization plot. Many plants have been hedged to the top of browse protector (photographs B and D). Plants that have grown above browse height have been browsed at all reachable locations (photograph C). Photograph E provides an example of plant height in July, just one month prior to the August monitoring site visit. It appears that most of the browse observed during monitoring occurred sometime between the end of July and the beginning of August.

Table 2. Summary of overall percent survival in Planting Units 1 and 7 in 2008 and 2010.

Planting Unit	Year	
	2008 Percent Survival	2010 Percent Survival
Planting Unit 1	100	91
Planting Unit 7	96	93

Solarization

In 2010, plant survival was monitored at both long-term planted solarization plots. Growth data were not collected during 2010 monitoring because the level of browse that occurred prior to monitoring removed the current year's growth (Figure 8). Table 3 compares combined survival for both plots between 2008 and 2010. Overall survival in 2008 was 95%. Overall survival in 2010 was 83%.

In both long-term plots, some of the plants appear to have died back but are re-sprouting from the root crown (Figure 9). This may explain some of the discrepancies in the monitoring numbers such as the increase in alder survival between 2008 and 2010. Overall, and for most species, survival remains high (above 80%). Serviceberry (*Amelanchier alnifolia*) survival decreased noticeably between 2008 and 2010 (from 100% to 33%), but only three serviceberry were installed in these plots so it is difficult to draw conclusions about overall serviceberry survival at the site.

Table 3. Survival of containerized plants installed within long-term solarization plots in 2008 and 2010.

Scientific Name	Common Name	2008 Percent Survival	2010 Percent Survival
Alnus incana	mountain alder	80	89
Amelanchier alnifolia	Western serviceberry	100	33
Betula occidentalis	water birch	100	100
Cornus sericea	red-osier dogwood	100	100
Crataegus douglasii	black hawthorn	100	89
Picea engelmannii	Engelmann spruce	33	0
Populus tremuloides	quaking aspen	100	100
Rosa woodsii	wood's rose	100	100
Salix spp	willow species	100	71
Spiraea betulifolia	white spirea	100	80
Overall Percent Survival		***95***	***83***

Figure 9. Photographs showing the various conditions found within the long-term planted solarization plots. Photograph A is an example of a containerized plant that has died back to the crown but is re-sprouting. Photograph B shows plants that have grown to the maximum capacity of the browse protector.

All three temporary solarization plots were observed during the August 2010 monitoring site visit. The fabric at Plot 3 was removed and the plot was seeded with a native species mix that included shrubs, forbs and grasses in October 2009. This plot appears to have had good germination of the seeded species (Figure 10). Some pasture grasses and reed canarygrass (*Phalaris arundinacea*) are encroaching into the seeded area. Plot 1 was observed during August 2010. Figure 11 shows the condition of the soil and solarized

vegetation at Plot 1 in August 2010. The fabric appears to have effectively killed the reed canarygrass that was present at this site. The vegetation under the solarization fabric placed at Plot 2 has also been effectively killed. There is a dense infestation of Canada thistle (*Cirsium arvense*) surrounding Plot 2.

Based on the above observations and the results of previous year's monitoring, the following adaptive management recommendations were made:

- Re-secure fabric at both long-term planted solarization plots in summer or fall 2010.
- Repair and re-secure browse protectors at both long-term planted plots in summer or fall 2010.
- Hand-pull weeds growing through the fabric at the base of plants at both long-term planted plots in summer or fall 2010.
- Water all plants in long-term planted plots in August 2010.
- Install additional long-term planted solarization plots in the lower portion of the project reach where reed canarygrass infestations are abundant in fall 2010.
- Remove fabric from Temporary Solarization Plot 1 and seed with a diverse native species mix.
- Place fabric removed from Temporary Solarization Plot 1 around exposed area to prevent re-colonization of undesired species.
- Leave Temporary Solarization Plot 2 in place until adjacent Canada thistle infestations are controlled. Fabric removal would result in an area of bare soil that would be very susceptible to thistle colonization.
- Re-secure fabric in Plot 2 during summer or fall 2010.

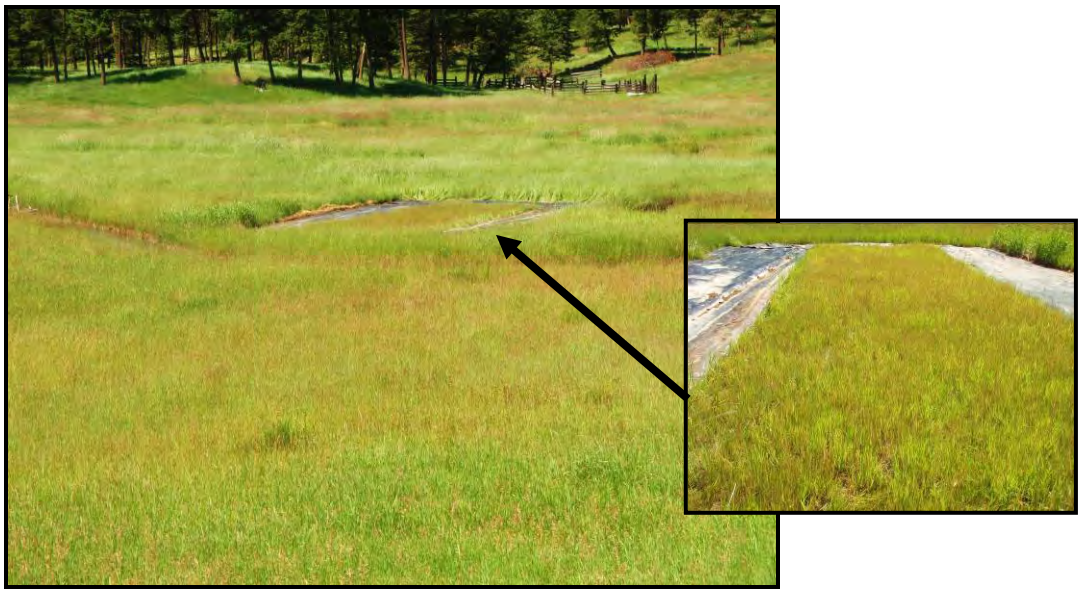


Figure 10. Photograph showing an overview and close-up (inset) of temporary solarization plot 3 during the first growing season after fabric removal.

Figure 11. Photograph showing the condition of the soil in Temporary Solarization Plot 1. All the undesirable reed canarygrass has been killed and a layer of organic matter is all that remains on top of the bare mineral soil.

Vegetated Soil Lift

Both vegetated soil lifts were observed during the August 2010 monitoring site visit. General observations of vegetated soil lifts indicate a similar trend as observed in previous years. Willow (*Salix spp.*) survival is patchy at both sites. Survival of willow cuttings is much higher above the lift than below at both sites. Surviving willows continue to be browsed which is resulting in minimal shoot height. However, percent cover of the surviving willows has increased resulting in a dense band of cover immediately along the channel at both sites (Figure 12). Both sites were evaluated for the feasibility of installing browse control measures. Given the small size of the channel, which allows access to the willows from both sides of the channel, and the immediate location of the willows to flowing water, physical barriers to browse would not be effective without posing a risk during high flows. A variety of chemical barriers are available but would require frequent application to be effective, especially given the location of the willows next to flowing water. The frequency of application required does not seem feasible. Although browse is limiting vertical growth, root growth is likely unaffected, at least in the short-term.

Based on the above observations and the results of previous year's monitoring, the following adaptive management recommendations were made:

- Hand-pull weeds at both vegetated soil lift sites in summer 2010.
- Re-secure exposed wooden stakes at both sites in summer or fall 2010.

Figure 12. Photograph of vegetated soil lift 1 showing a dense but suppressed band of willow growth along the face of the lift.

Willow Fascines

All willow fascine sites were observed in August 2010. Each site was photographed and general observations of treatment effectiveness were recorded. Survival of willows in willow fascines is highly variable (Figure 13). Most of the fascines continue to function for trapping debris and sediment. Some fascines have established into dense patches of vegetation within the channel margins. Other fascines have minimal willow growth, but are functioning for trapping debris and sediment to create roughness within the channel margins. Similar to other treatments where willow cuttings were installed, many willow fascines have been browsed resulting in limited shoot growth.

Based on the above observations and the results of previous year's monitoring, no adaptive management recommendations were made.

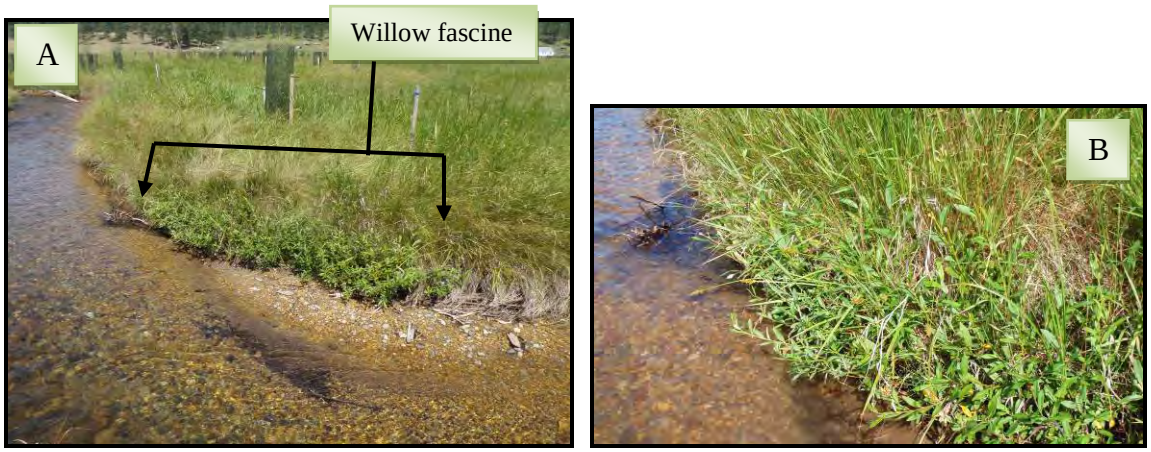


Figure 13. Photographs show the various conditions of willow fascines. Photographs A and B are examples of fascines where the willow cuttings have taken root and are becoming dense patches of vegetation within the channel margins. Photos C and D are examples of fascines where scour (D) and deposition (C) have occurred but minimal willow growth is occurring.

Large Woody Debris Structures

All woody debris structures were observed in August 2010. Each site was photographed and general observations of the condition and function of each large woody debris structure were made. Debris continues to accumulate in and around the structures (Figure 14). Colonization of willow seedlings was observed in deposition within two of the woody debris structures. The species composition of the surrounding floodplain remains dominated by non-native pasture grasses but there are patches of wetter vegetation such as sedges and rushes establishing. No obvious change in species composition has occurred since 2009 monitoring. Shifts in species composition are often slow changes that occur over time. Since native seed sources are present, it is expected that the site will continue to slowly convert to a wet meadow with more diverse native species over time.

Based on the above observations and the results of previous year's monitoring, no adaptive management recommendations were made.

Figure 14. Photographs showing the conditions at the large woody debris structure sites and the surrounding floodplain.

Coir Logs

All coir log sites were observed in August 2010. Each site was photographed and observations of willow survival, growth and overall treatment effectiveness were recorded. Overall survival of willow cuttings appears to be consistent with data collected in 2009. Willow cutting growth is continuing but is slower than expected. Browse of willows was observed at almost every coir log site and this is likely a major factor affecting shoot growth on willows. Although top growth is being limited by browse, it is not likely affecting root development of the willow cuttings. Tall pasture grasses continue to dominate the banks adjacent to coir logs and may be limiting the availability of light reaching the willows. Similar to the vegetated soil lifts though, the surviving willow cuttings are beginning to form a dense band of woody vegetation along the streambanks (Figure 15). Potential measures for controlling browse on willow cuttings installed in coir logs were evaluated, but none were recommended for similar reasons as those described above for vegetated soil lift sites.

Although pasture grasses dominate the streambanks at these sites, it does appear that percent cover of wetter species, such as sedges are increasing immediately along the channel at these sites. This may indicate that coir logs are functioning to increase moisture in these banks late in the growing season resulting in a transition to wetter species.

Based on the above observations and the results of previous year's monitoring, no adaptive management recommendations were made.

Figure 15. Photographs show the short, but dense patches of willows growing from the coir logs. Sedge species have also started to dominate the streambank area immediately adjacent to the coir logs.

Herbicide Application

Weed mapping was completed for the project reach in July 2009 and is described in the 2009 monitoring and maintenance report (Geum Environmental, December 2009). Weed mapping was not repeated in 2010 but general observations on the effectiveness of previous year's treatments and expansion of infestations were made. Weed control efforts have been effective in controlling most of the target species. Canada thistle remains the primary target species and is still widespread throughout the project reach. Densities are greatly reduced in the upper portion of the reach however large, dense infestations remain in the lower portion of the reach. This lower section has been missed during a number of previous herbicide applications at the site and as a result there is a noticeable difference between infestation sizes compared with the upper portion of the project.

Herbicide applications targeting reed canarygrass in the upper portion of the project reach also appear to be effective (Figure 16). A few patches remained in this area in August 2010. Reed canarygrass remains a dominant species in the lower portion of the project reach.

Based on the above observations and the results of previous year's monitoring, the adaptive management recommendations were made:

- Complete herbicide application recommendations provided in the 2009 monitoring and maintenance report in summer and fall 2010.

Figure 16. Photographs showing small patches of reed canarygrass after summer herbicide treatment.

2010 Maintenance

As described in the previous section, maintenance requirements for revegetation treatments were determined during 2010 effectiveness monitoring. Phase I and II treatments required minimal maintenance in 2010. Maintenance tasks completed in July and August 2010 included:

- Watering of all installed plants and protected residual shrubs with a minimum of five gallons of water using a slow release method so that water infiltrated into the soil.
- Hand-pulling of weeds on vegetated soil lifts.
- Re-securing wooden stakes that had loosened along the back edge of vegetated soil lifts.
- Re-securing temporary and long-term solarization fabric in all plots.
- Weeding around the base of plants installed within the long-term planted solarization plots.
- Re-securing and straightening browse protectors that had been damaged by ungulates or environmental factors, such as snow and wind.

2010 (Phase III) Revegetation Treatments

This section provides details on each of the five riparian revegetation treatments completed between October 2 and October 9, 2010. To document as-built conditions, all treatment locations were recorded using a resource-grade global positioning system (GPS) unit. Locations were imported into ArcView 10 and georeferenced to a 2009 National Agriculture Imagery Program (NAIP) aerial photograph of the project site. Locations of 2010 treatments are shown in Figures 1 and 17.

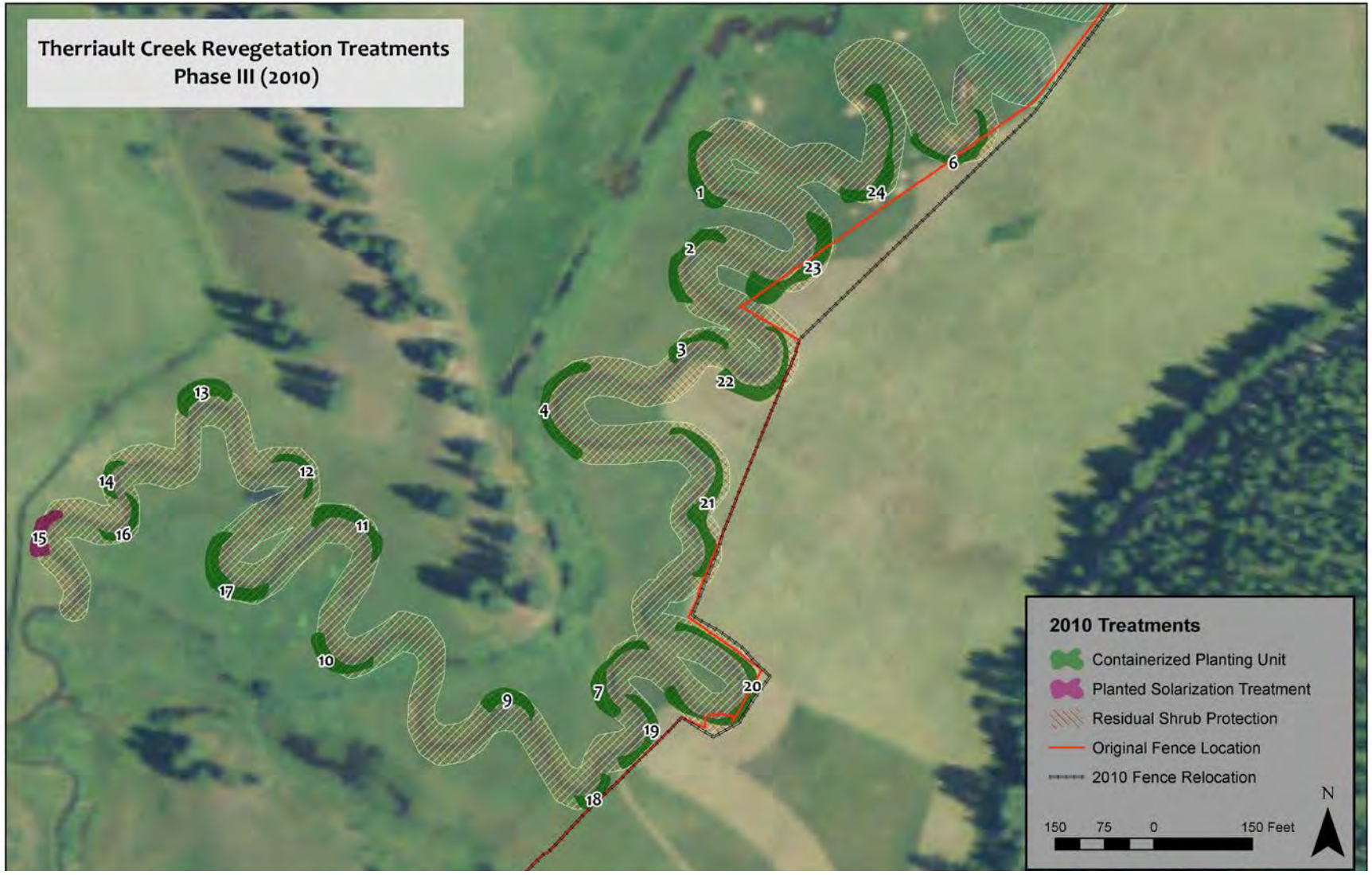


Figure 17. Aerial photograph showing the locations of Phase III (2010) riparian revegetation treatments at the Therriault Creek project site. Figure 1, above, shows these treatments in relation to the Phase I (2007) treatments.

Residual Shrub Protection

A total of 154 shrubs remaining from planting during initial channel restoration were fitted with browse protectors to complete this task. Residual shrub protection included installing four-foot tall, sixteen-inch diameter rigid plastic mesh browse protectors to protect shrubs from deer and elk browse. Browse protectors were installed using five, UV stabilized cable ties and two, two-inch by two-inch by forty eight-inch wooden posts. Residual shrubs are located throughout the project reach along inner and outer meander bends. The general location of residual shrub protection areas are shown in Figures 1 and 17.

Residual shrubs selected for protection showed signs of heavy browse (Figure 18). All of the remaining surviving shrubs that could be located within the project reach were protected in 2010. The majority of residual shrubs are red-osier dogwood (*Cornus sericea*) and sandbar willow (*Salix exigua*).

Figure 18. Photograph showing the typical size of residual shrubs that were targeted for protection. Most shrubs were multi-stemmed and less than a foot tall.

Containerized Planting

A total of 1,100 containerized shrubs and trees were planted to complete this task. Plants were installed within twenty-two separate planting units, including one long-term, solarization site (Figures 1 and 17). All planting units were located along outside meander bends to promote long-term channel stability. Two species mixes were used depending on the topography and depth to water table of the planting site. Species planted in lower or wetter planting units included Drummond's willow (*Salix drummondiana*), Booth's willow (*Salix boothii*), bebb willow, sandbar willow (*Salix exigua*), water birch, red-osier dogwood, and quaking aspen (*Populus deltoids*). Species planted in higher or slightly drier areas included western serviceberry, snowberry (*Symphoricarpos occidentalis*), alder, bebb willow, Drummond's willow, Booth's willow, and red-osier dogwood. Conditions of typical planting units are shown in

Figures 19 and 20. Table 4 provides a complete list of species planted in Phase III planting units. Thirty-nine of the 1,100 plants were planted in a planting unit where solarization fabric was installed prior to planting. This planting unit is described under the Solarization Task below.

Containerized shrubs and trees planted during Phase III were grown in tall one gallon (4-inch x 4-inch x 14-inch), 99 cubic inch, short one gallon, and short two gallon containers. A nine-inch auger bit mounted on a tracked skid steer was used to drill planting holes and remove thick pasture grass sod mats. Each plant was fitted with a vole protector, brush blanket, and four-foot tall, sixteen-inch diameter browse protector (Figures 19 and 20). Vole protectors were constructed with six-inch corrugated plastic drainage pipe cut into seven-inch lengths. Vole protectors were buried approximately three inches deep, leaving four inches above ground to protect the plant stem from girdling by voles and other rodents. An approximately two inch deep layer of wood bark mulch was placed within each vole protector to prevent grasses and weeds from establishing around the plant stem and retain moisture around the plant.

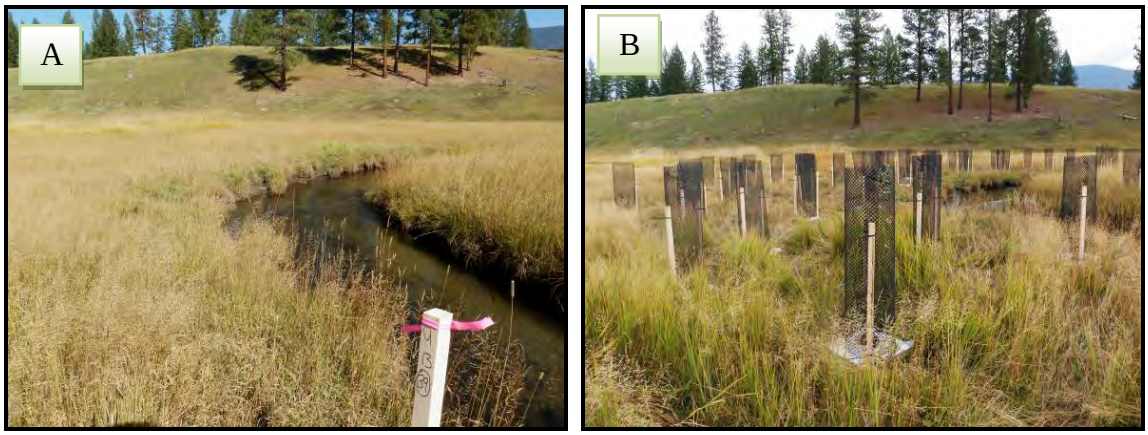


Figure 19. Photograph A shows Planting Unit 13 prior to plant installation. Photograph B shows Planting Unit 13 immediately after installation of containerized plants, browse protectors, vole protectors and brush blankets.

Table 4. Species, and quantities of containerized plants installed along Therriault Creek during Phase III revegetation.

Scientific Name	Common Name	Quantity Installed	Container size
Cornus sericea	red-osier dogwood	200	Tall 1 gallon (4'x4"x14")
Salix drummondiana	Drummond's willow	214	Tall 1 gallon (4'x4"x14")
		6	16 gallon grow bag
Salix boothii	Booth's willow	160	Tall 1 gallon (4'x4"x14")
Salix bebbiana	bebb willow	290	99 cubic inches
Salix exigua	sandbar willow	65	99 cubic inches
Populus tremuloides	quaking aspen	50	99 cubic inches
Alnus incana	mountain alder	20	Tall 1 gallon (4'x4"x14")

Scientific Name	Common Name	Quantity Installed	Container size
Betula occidentalis	water birch	40	Short 1 gallon
Symphoricarpos albus	snowberry	35	Short 1 gallon
Amelanchier alnifolia	western serviceberry	20	Short 2 gallon
	Total	1,100	

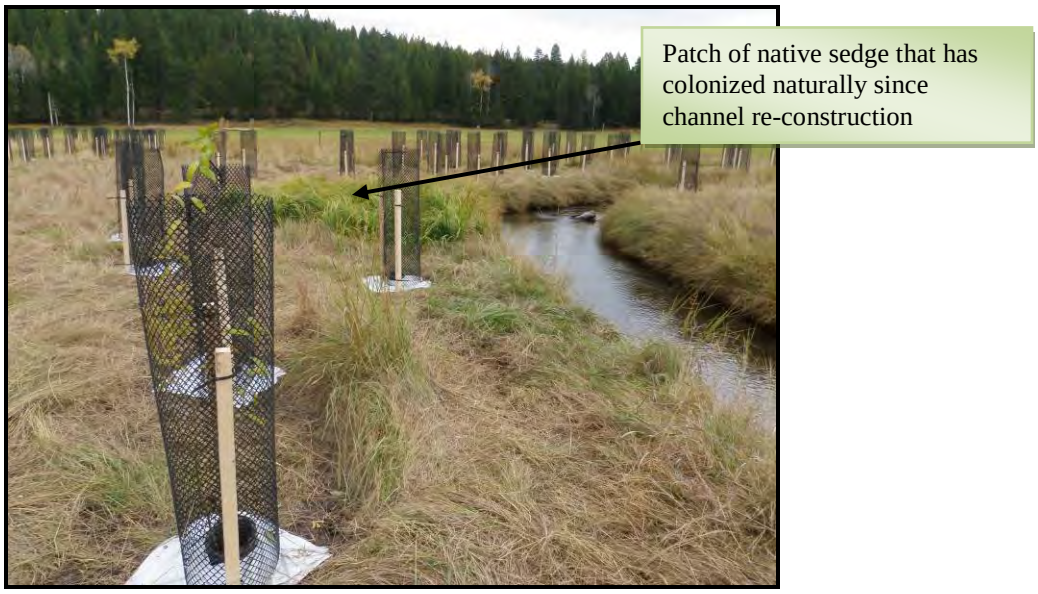


Figure 20. Photograph showing a typical Phase III planting unit along an outer meander. Note the patch of sedges that has colonized along the channel. Existing desired vegetation such as this was left undisturbed.

Solarization

A total of 1,580 square feet of solarization fabric was installed at one site to complete this task (Figure 17). Solarization is a method of weed control using black, woven geotextile fabric to heat the soil and either stimulate the existing seed bank to germinate or kill seeds with thin seed coats, such as many pasture grasses. The solarization plot is located along an outer meander bend at the downstream end of the project site where reed canarygrass infestations are abundant. A total of 39 plants were planted through the fabric at this site.

Fabric was placed in various configurations to best fit the curve of the outer meander at this site. Fabric was stretched tightly and secured using eight-inch staples at an approximate spacing of one staple per two square feet. The outside edges of the fabric were secured by trenching two feet of the fabric edge into the existing ground (Figure 21). Table 5 provides a list of species installed in the long-term planted solarization plot.

Fabric was removed from Temporary Solarization Plot 1. This plot was then seeded with a native seed mix. The seed mix is provided in Table 6.

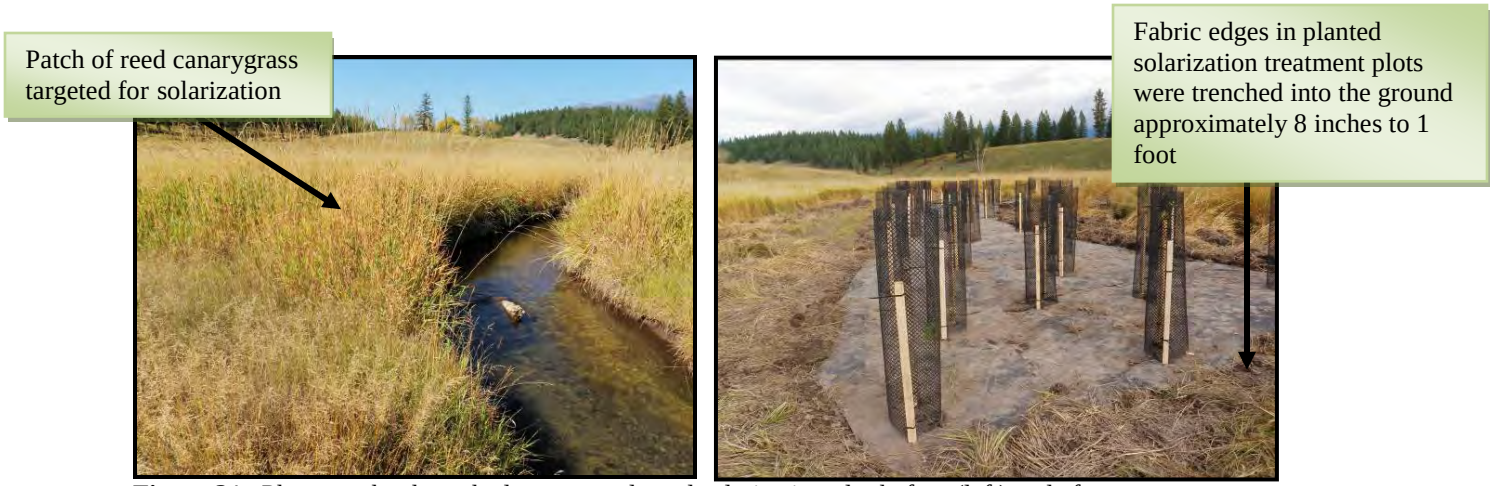


Figure 21. Photographs show the long-term planted solarization plot before (left) and after treatment (right).

Table 5. Containerized plant species installed within the long-term planted solarization plot.

Scientific Name	Common Name
Cornus sericea	red-osier dogwood
Populus tremuloides	quaking aspen
Salix drummondiana	Drummond's willow
Salix exigua	sandbar willow
Salix bebbiana	bebb willow

Table 6. Native Seed mix applied to Phase 1 Temporary Solarization Plot 1 after fabric removal.

Scientific Name	Common Name
Carex stipata	sawbeak sedge
Carex rostrata	beaked sedge
Juncus ensifolius	daggerleaf rush
Cornus sericea	red-osier dogwood
Prunus virginiana	chokecherry
Glyceria grandis	American mannagrass
Poa palustris	fowl bluegrass
Deschampsia cespitosa	tufted hairgrass

Herbicide Application

Two herbicide applications occurred during 2010; July 17and September 24. Targeted weed species included Canada thistle, reed canarygrass, yellow toadflax, houndstongue (*Cynoglossum officinale*) and sulphur cinquefoil. The 2009 monitoring report discusses the density and distribution of each of these weeds in detail and provides the recommendations that formed the basis for 2010 treatments. Weed infestations along the entire project reach were targeted for treatment. Care was taken in and around planting units to minimize damage to non-target species.

Riparian Fence Relocation

A riparian fence was installed along the east boundary of the restoration project by the land lessee in 2009. The installed fence encroached on the constructed channel in some locations, limiting the area available for planting the desired riparian buffer along the

stream. To address this issue and create sufficient space for planting a riparian buffer along the channel, the installed fence was realigned in some areas. Geum provided fence re-alignment recommendations, flagged the recommended fence line location and removed the fence during installation of Phase III revegetation treatments. A Montana Conservation Corps (MCC) crew installed the new fence in late October 2010 (Figure 22). The original fence location and approximate location of the re-aligned section of fence are shown in Figure 17.

Figure 22. Photograph shows the MCC crew working on the fence re-location in October 2010.

Adaptive Management: Next Steps

This section provides recommendations for continued monitoring, maintenance and revegetation activities at the Therriault Creek restoration project site. Effectiveness monitoring should continue in 2011. For Phase III treatments, monitoring should be completed to establish baseline conditions and ensure that treatments are achieving project goals and to identify maintenance needs. Monitoring methods should be similar to those described in previous reports. For revegetation treatments installed during Phase I and II, monitoring in 2011 should consist of a monitoring evaluation site visit, similar to what was completed in 2010. No observations or data collected in 2010 indicate that the trends at the site are different than what was observed in previous years. Monitoring of Phase I and II treatments in 2011 should focus on determining any maintenance needs of Phase I and II treatments and verify site trends. Monitoring recommendations for 2011 are listed below. Table 5 provides a revised decision pathway for evaluating continued effectiveness of treatments and maintenance needs at the site.

- Monitoring evaluation site visit of Phase I and II treatments that includes:
    - Photo documentation of all treatments;
    - Survival monitoring of the four planting units monitored in 2010;
    - Qualitative observations of all treatments; and
    - Documentation of maintenance needs.

- Monitoring of Phase III treatments including:
    - Survival monitoring of approximately 40 percent of the total number of plants installed;
    - Photo documentation of all treatments; and
    - Documentation of maintenance needs.

In addition to monitoring, maintenance activities will be required at the site. Maintenance of Phase III revegetation treatments and continued maintenance of treatments installed in previous project phases will continue to be key to achieving project goals. As described above, monitoring conducted in summer 2011 should be done to determine the actual maintenance activities needed at the site. Treatments installed during Phase I and II should require minimal maintenance. Phase III treatments will require maintenance activities such as watering, browse protector replacement or repair. The following revegetation treatment maintenance tasks may be required in 2011:

- **Browse Protector Maintenance**. Browse protectors installed around plants planted during Phase III are a larger diameter than initially installed in Phase I. Therefore, browse protector expansion will not likely be required for Phase III plants until year two or three. Some plants in Phase I have grown to a sufficient size that browse protectors can be removed. Any browse protectors that were not expanded during maintenance activities completed so far should be expanded in 2011. Browse protector repair will also likely be required in 2011.
- **Watering.** For Phase III plants, watering should occur at least twice during the hottest and driest part of the 2011 growing season. All plants should be deep watered with at least 10 gallons of water per watering event. The need to water

Phase I plants should be assessed during monitoring and based on weather conditions.

- **Solarization Maintenance.** Solarization fabric, both temporary and long-term, will likely require some maintenance in 2011. Maintenance activities may include re-securing fabric edges and loose staples or hand-pulling weeds from around the base of plants in long-term plots.

In addition to continued monitoring and maintenance of installed revegetation treatments, some follow-up tasks related to revegetation treatments previously implemented at the site are recommended. These tasks include:

- **Fabric Removal and Seeding of Temporary Solarization Plot 2**. The remaining temporary solarization plot could be removed during spring 2011 depending on adjacent weed densities.
- **Re-seeding and Expansion of Temporary Solarization Plots 1 and 3**. Based on continued observation of these plots, re-seeding may be necessary. Fabric that was removed from these plots and placed as a buffer along the exposed area should continue to be moved outward from the treated area based on observations that the grasses and other undesirable species have been effectively killed.
- **Fabric Removal and Seeding of Long-term Planted Solarization Plots**. Patches of fabric in the Phase I long-term planted treatment plots 1 and 2 could be removed in spring 2011 depending on the condition of the soil beneath the fabric. Fabric removal should be focused around plants that sucker or have a shrubby growth form, such as willows and dogwood. Solarization fabric installed during Phase III (Planting Unit 15) should remain in place for at least three growing seasons. Removal will depend on adjacent weed infestations.
- **Herbicide Application**. Herbicide application should continue at the site until target infestations are under control. Herbicide treatment priorities include :
    - Infestations of Canada thistle in the lower portion of the reach should be aggressively treated.
    - Canada thistle, yellow toadflax, houndstongue, sulphur cinquefoil and any other noxious weeds should continue to be spot treated throughout the project reach.
    - Continue to target isolated patches of reed canarygrass remain in the upper portions of the project reach.

If 2011 monitoring indicates similar trends to previous year's monitoring it will not be necessary to continue annual effectiveness monitoring at the site. The site should continue to be visited annually to determine maintenance needs and evaluate the need to collect further effectiveness monitoring data in the future.

Table 7. Decision pathway for 2011 effectiveness monitoring and adaptive management.

Treatment	Treatments Implemented in Fall 2010 (Phase III)	2011 Effectiveness Monitoring	Decision Pathway for Maintenance and Adaptive Management
Residual shrub protection	154 residual shrubs protected	Monitor a select number of Phase III shrubs for new growth. Record visual observations of shrubs protected during Phase I and II.	(1) If protected shrubs are greater than 3 feet above the height of the browse protector, browse protectors should be removed. If plants are less than 3 feet above the height of the browse protector, leave the protector in place. (2) If protected shrubs have filled greater than 80% of the capacity of the browse protectors, expand protector to accommodate growth. (3) If hedging of protected shrubs is occurring at the height of the browse protector, evaluate the effects on the health of the plant. If the plant appears healthy, no action is needed. If the plant appears stunted or otherwise unhealthy, additional measures for protection may need to be evaluated.
Containerized plantings	1,100 plants installed (22 planting plots)	Monitor a select number of Phase III plots for survival representing approximately 40 percent of the installed number of plants. Monitor Planting Units 1 and 7 in Phase I.	(1) If survival of containerized shrubs in Phase III is good (>80%), reduce the frequency of monitoring at the site. Continue to conduct annual maintenance site visits and implement necessary maintenance. (2) If survival is poor, determine if additional irrigation or weed suppression measures are needed or if other site conditions are precluding growth (e.g. soils). If limitations to survival are identified, consider re-planting poor survival areas.
Solarization	Planted (1,508 ft^2, 39 plants)	Monitor all planted solarization plots installed in Phase I and III.	(1) If survival remains above 80%, reduce the frequency of monitoring at the site. Continue to conduct annual maintenance site visits and implement necessary maintenance. (2) If survival remains above 80% begin fabric removal around select shrubs in Phase I sites. Leave fabric installed in Phase III in place. (3) If survival drops below 80%, try to determine causes. Consider

Treatment	Treatments Implemented in Fall 2010 (Phase III)	2011 Effectiveness Monitoring	Decision Pathway for Maintenance and Adaptive Management
			removing fabric and re-planting once causes are determined.
Solarization Temporary	Fabric removal and seeding in Plot 1 24'x50' (Phase I)	Visual observations and photographs of Phase I treatment effectiveness.	(1) If percent cover of seeded or other desirable species is greater than 70%, expand plots to treat additional area and continue to evaluate sites each year for maintenance needs. (2) If percent cover of seeded or other desirable species is less than 70% and undesirable species are not present or less than 10% total cover, re-seed with native species. Consider adding soil amendments such as compost or mulch if appropriate. (3)) If percent cover of seeded or other desirable species is less than 70% and undesirable species are present and greater than 10% total cover, try to determine causes and consider re-treatment with solarization fabric or chemical control once causes have been identified.
Vegetated Soil Lifts	None	Visual observations and photographs of Phase I treatment effectiveness.	(1) If willow shoot height remains below 3 feet and overall percent cover is not increasing, apply chemical barriers to browse. (2) If willow shoot height is greater than 3 feet or density appears the same or increasing take no further action.
Coir Logs	None	Visual observations and photographs of Phase I treatment effectiveness.	(1) If willow shoot height remains below 3 feet and overall percent cover is not increasing, apply chemical barriers to browse to allow willows to grow and become more resistant to browse. (2) If willow shoot height is greater than 3 feet or density appears the same or increasing take no further action.
Willow fascines	None	Visual observations and photographs of Phase I treatment effectiveness.	Take no further action.

Treatment	Treatments Implemented in Fall 2010 (Phase III)	2011 Effectiveness Monitoring	Decision Pathway for Maintenance and Adaptive Management
Large Woody Debris Structures	None	Visual observations and photographs of Phase I treatment effectiveness.	(1) If species composition adjacent to structures appears to have shifted, repeat transect monitoring to evaluate trend. (2) If species composition adjacent to structures appears to have not changed, continue to make annual visual observations of treatment effectiveness. Repeat transect monitoring in 2012.
Herbicide application	Two applications targeting noxious weeds and reed canarygrass.	Monitor continued spread and effectiveness of control.	(1) If noxious weed infestations are documented, continue to treat infestations. (2) Continue to monitor new infestations of Canada thistle, reed canarygrass, yellow toadflax, houndstongue, sulphur cinquefoil and any new weed species identified.

References

Geum Environmental Consulting, Inc. 2007a. Therriault Creek Riparian Revegetation Plan. Internal report prepared for Kootenai River Network, Libby, Montana.

Geum Environmental Consulting, Inc. 2007b. Therriault Creek Implementation Report. Internal report prepared for Montana Fish, Wildlife and Parks, Libby, Montana. Contract #080067.

Geum Environmental Consulting, Inc. 2008. Therriault Creek Riparian Revegetation Monitoring Report Contract #0803. Internal Report prepared for Kootenai River Network, Libby, Montana.

Geum Environmental Consulting, Inc. 2009. Therriault Creek Riparian Revegetation Maintenance and Monitoring 2009 Report Contract #0709. Internal Report prepared for Kootenai River Network, Libby, Montana.

Appendix A: Planting Unit Photograph Documentation

Planting Unit 1

2008

2009

2010

Planting Unit 3

2008

2009

2010

Planting Unit 5

2008

2009

2010

Planting Unit 7

2008

2009

2010

Planting Unit 12

2008

2009

2010

Planting Unit 14

2008

2009

2010

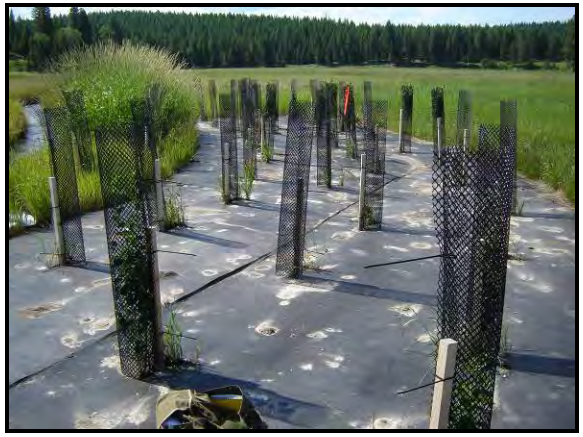
Planting Unit 16

2008

2009

2010

Planted Solarization Unit 1



2008

2009

2010

Planted Solarization Unit 2

2008

2009

2010

Appendix B: Vegetated Soil Lift Photograph Documentation

Vegetated Soil Lift 1

Vegetated Soil Lift 2

Appendix C: Coir Log Photograph Documentation

Coir Log 1

2008

2009

2010

Coir Log 2

2009

2010

Coir Log 3

2008

2009

2010

Coir Log 4

2008

2009

2010

Coir Log 5

2008

2009

2010

Coir Log 6

2008

2009

2010

Coir Log 7

2008

2009

2010