





Huu-ay-aht First Nation

huu ay aht

ANCIENT SPIRIT, MODERN MIND

Sarita and Pachena Watershed Renewal: Habitat Assessment and Prescriptions for Riparian Restoration Measures for the Sarita Watershed 2019 Update

Prepared by

Symmetree Consulting Group, LGL Limited, and Meridian Forest Services

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Habitat Assessment and Prescriptions for Riparian Restoration Measures for the Sarita Watershed Huu-ay-aht Traditional Territory 2019 Update

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EXECUTIVE SUMMARY

Renewal of the Sarita and Pachena watersheds requires an ecosystem-based approach that recognizes the interconnections between community, land, water, and biota. The overarching vision is to restore the Sarita and Pachena watersheds to support fish and wildlife populations and cultural values for present and future generations. The Renewal Framework (Adama and Bocking 2017) identified several assessments and inventories that could be conducted to address known information gaps relating to the condition of the Sarita and Pachena watersheds. The purpose of these assessments and inventories will be to specify where and what kinds of renewal actions are required to achieve short- and long-term renewal goals (such as restoring watershed processes, fish habitat and productivity, estuary productivity, wildlife habitat and populations, and species at risk).

Riparian restoration was highlighted as a key component of ecosystem and watershed restoration. Thus, in August 2017, several riparian areas along identified stream reaches in the Sarita Watershed were assessed for possible instream enhancement and silviculture prescriptions. Initial reconnaissance found a range of conditions that would benefit from Riparian Renewal Treatments. Opportunities were further scouted in 2018 and 2019 in several other reaches of the Sarita River (e.g., upstream of Sarita Lake) and in the Pachena River Watershed. These areas were revisited and those deemed suitable for treatment were selected for further restoration work.

To date, we have treated a total of 1.0705 ha of riparian habitat, including 0.8975 ha (35 polygons) in the Sarita Watershed and 0.173 ha (10 polygons) in the Pachena River Watershed. The most common treatment application was brushing to remove thick understory vegetation (45 polygons), which is necessary to reduce competition with transplanted seedlings. Thirty-eight polygons (0.9234 ha) were planted along the Sarita River, the South Sarita River, Sabrina Creek, and Pachena River. Twenty-six of these planted polygons also received girdling treatment to slowly kill overhead deciduous tree, thereby reducing light competition for the transplanted seedlings. In addition, potential areas for future treatment were delineated and mapped in the Sarita River Watershed (46 polygons along the Sarita River, upstream of Sarita Lake; total area = 1.498 ha).

Planted areas received Sitka spruce (*Picea sitchensis*) and western redcedar (*Thuja plicata*) transplants, with a target planting density of 2,500 stems per ha (sph). The planting was done by Meridian Forestry and Huu-ay-aht First Nation crew members. Actual number of stems planted depended on available microsites, flooding potential, brush ingress, soil types, etc. Thus, the final transplant density varied by site and species. The average density of western redcedar was 2,841.7 sph. Spruce transplants were slightly more densely spaced at an average of 2,984.4 sph. Nineteen polygons were planted with western redcedar (0.4975) and 19 polygons were planted with Sitka spruce (0.4259 ha).

Browsing (primarily by black-tailed deer [*Odocoileus hemionus*]) is particularly damaging to freshly planted western redcedar seedlings, often beyond the point of recovery. Thus, Freegro browse guards were installed on 89% planted western redcedar (17 of 19 polygons) and 26% Sitka spruce (5 of 19 polygons) to prevent damage to young seedlings from deer and newly transplanted elk (*Cervus canadensis*). The two unprotected cedar polygons (Sarita River MFS 6 & 8) are planned to be fitted with browse guards in Spring 2020. Rodent damage, improper fertilizer placement, and planting error explained other minor seedling mortality cases.

Girdling is expected to result in deciduous tree die-off several years post-treatment. During follow-up monitoring, approximately 20% of polygons were found to have an unacceptable number of trees improperly or not fully girdled to the extent required to successfully kill the tree. These polygons have had a second pass to ensure gridling is complete.

Each treatment area has been revisited and monitored one year after planting. Eighty percent of polygons have shown minor mortality of planted seedlings, considered to be within limits of acceptable mortality.

There has been follow up brushing, shelter recovery, and fill planting in areas where there was initial heavy mortality.

The following is a summary of work completed for this component of the Sarita and Pachena Watershed Renewal Project, current to July 2019. For details on previous work, please see Bancroft et al. (2018).

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John Kendall (JKFC & Freegro Enterprises, Sidney, B.C.) provided the Freegro open mesh browse guards, manufactured by the Cowichan Valley First Nations. Sylvan Vale Nursery Ltd. (Black Creek, B.C.), Arbutus Grove Nursery (Saanich, B.C.), and Western Forest Products (Vancouver, B.C.) provided tree seedling stock for the restoration treatment polygons. Transplant fertilizer packs (T-bags) were acquired from Reforestation Technologies International (Gilroy, CA).

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INTRODUCTION

Riparian Renewal

Riparian renewal is the process of returning natural parts of the stream edge forest that over centuries helped create the conditions that fish need for their survival. Historically, riparian habitats in the Sarita and Pachena watersheds were dominated by large conifers that shaded and protected stream banks and provided a source of large woody debris (LWD). These trees periodically died and fell into the river, creating small dams that formed pools and shallow areas that are key habitats for fish. Tree roots and LWD influence the shape of rivers. In addition, as trees in the riparian area drop their needles or leaves, these provide nutrient inputs to the river.

However, timber harvesting practices in the 1950s and 1960s removed old growth and mature forest within these watersheds up to the edge of the rivers and streams. This intensive harvesting eliminated the source of the roots and stems that are important to fish and other wildlife. This practice greatly altered the riparian habitat by disrupting the cycle of LWD input. Impacts to fish and fish habitat from forestry are well documented in these watersheds (Bocking et al. 1997; Horel 1997, 2008; Keystone 2006; Barry 2010). The loss of mature coniferous forest in the riparian zone has contributed to channel/bank erosion, channel widening, the infilling of pools, reduced surface flow, and the loss of LWD from streams (Bocking et al. 1997; Horel 1997; Ochman 1998).

Riparian zones in these areas are now dominated by a deciduous canopy of red alder (*Alnus rubra*) and bigleaf maple (*Acer macrophyllum*). While alder establishes rapidly and provides some ecosystem benefits (e.g., nitrification, leaf litter, wildlife habitat), it is an inadequate source of LWD due to its short-term persistence, offers limited channel bank stabilization, and does not provide adequate stream cover or shading (Slaney and Martin 1997). Moreover, alder outcompetes conifers for light delaying re-establishment.

To deal with the loss of key stream features, wood and rocks are being reintroduced under the renewal program to help create functional stream habitat for the future (Figure 1). However, these structures will eventually decay and be broken down overtime, so it is important to plant coniferous trees along the rivers and streams in order to re-establish the cycle of LWD supply.

The restoration[1] of conifer-dominated riparian habitat is one of the highest priorities identified in restoring the Sarita Watershed (Bocking et al. 1997; Horel 1997, 2008; Barry 2010). Priority areas for riparian restoration in the Sarita and Pachena watersheds were identified by Bocking et al. (1997), Horel (1997 and 2008), Ochman (1998), and Barry (2010). We confirmed priority areas for treatment in 2017 and 2018 through ground reconnaissance assessments.

[1] Herein, the term "restoration" is broadly defined as ecosystem restoration, rehabilitation, remediation, enhancement, improvement, mitigation, reclamation, and/or other terms used to describe activities meant to restore ecological processes or improve habitats or ecosystems (Hobbs and Norton 1996; Roni and Beechie 2012).



Figure 1 Established conifer along Sabrina Creek (reach 34) used for anchoring of additional LWD benefiting stream bank stability and channel morphology. These complementary riparian renewal activities provide an immediate source of LWD, while re-establishing conifer-dominated forests will provide a long-term source of LWD.

Purpose and Objectives

The overarching vision of the renewal framework is the restoration of the Sarita and Pachena watersheds to support fish and wildlife populations and cultural values for present and future generations (Adama and Bocking 2017). The purpose of this project is to identify and implement Riparian Zone Silviculture opportunities to provide for long term creation of LWD in the Sarita and Pachena watersheds. The lack of LWD has been clearly described by Barry (2010) for several reaches within the Sarita Watershed. The intent is to provide long term supplies of LWD to assist in maintaining bank stability, stream morphology, and riparian function. This was identified as a key component of making the Sarita River system sustainable over the longer term.

This component of the renewal program involves (but is not limited to) the following major processes:

1. Identify suitable areas where added conifers would benefit the stream or river over the long term. This was done by on-the-ground assessments of riparian vegetation types, noting areas with potential for treatment success.
2. Control deciduous vegetation and brush. As many areas of the river/stream banks have been colonized by shrubs and short-lived alder there is a need to control that vegetation to allow planted conifers to get the needed light for their survival and growth. This is done by brushing and girdling treatments. Areas with potential overhead danger from girdled trees are appropriately signed.
3. Establish coniferous tree species along the rivers. Both western redcedar (*Thuja plicata*) and Sitka spruce (*Picea sitchensis)* were chosen transplant species for treatment areas. Both are long-lived conifer species native to the Coastal Western Hemlock zone (CWH) biogeoclimatic zone of these watersheds, that will provide solid roots and good in-stream sources of large woody debris over time.
4. Seedling protection. Browse guard installation will protect attractive transplant seedlings (especially western redcedar) from deer (*Odocoileus* sp.) and elk (*Cervus canadensis*) browsing activity.

5. Follow-up monitoring and maintenance. The sites are being monitored to promote success in re-establishing a long term and sustainable supply of wood for the streams. Secondary brush control, girdling, and in-fill planting are key to treatment success. Follow-up monitoring is also necessary to recover browse guards for redeployment.

Study Area

The Sarita and Pachena watersheds are located on the West Coast of Vancouver Island, adjoining Barclay Sound (Figure 2). It is the traditional territory of the Huu-ay-aht First Nation. The Sarita drainage includes several major tributaries with the South Sarita River and Sabrina Creek being the two main tributaries.

Biogeoclimatic Ecosystem Classification (BEC) zones provide ecosystem classifications that reflect the climate, topography, soils, and vegetation. A single biogeoclimatic zone the Coastal Western Hemlock zone (CWH) covers the Sarita and Pachena watersheds (Figure 2). Western hemlock is usually the most common tree species in these forests, followed by western redcedar and Douglas-fir (*Pseudotsuga menziesii*; Pojar et al. 1991). Sitka spruce is a widespread species in the CWH but is largely restricted to floodplains and exposed beaches. Red alder is a widespread species on logged and otherwise disturbed sites.

The CWH zone comprises three subzone variants: the CWH submontane very wet maritime (CWHvm1), CWH montane very wet maritime (CWHvm2), and CWH southern very wet hypermaritime (CWHvh1). Currently, our riparian renewal activities are confined to sites within the CWHvm1 subzone.

The CWHvm1 is the most extensive biogeoclimatic variant on the coast of BC and within the Sarita and Pachena watersheds. It occurs at low elevations (0–400 m above sea level [asl]), has wet humid climate with cool summers and mild winters again with little snow. Growing seasons are long resulting in good growing sites for conifers. Precipitation is high but can vary considerably, with extreme events again near the Pacific Ocean. Typical sites are dominated by western hemlock (*Tsuga heterophylla*), amabilis fir (*Abies amabilis*), and western redcedar with a well-developed shrub layer dominated by red huckleberry (*Vaccinium parvifolium*) and Alaskan blueberry (*V. alaskaense*). High bench sites are dominated by salmonberry (*Rubus spectabilis*). Western redcedar, amabilis fir, and Sitka spruce are recommended confers.

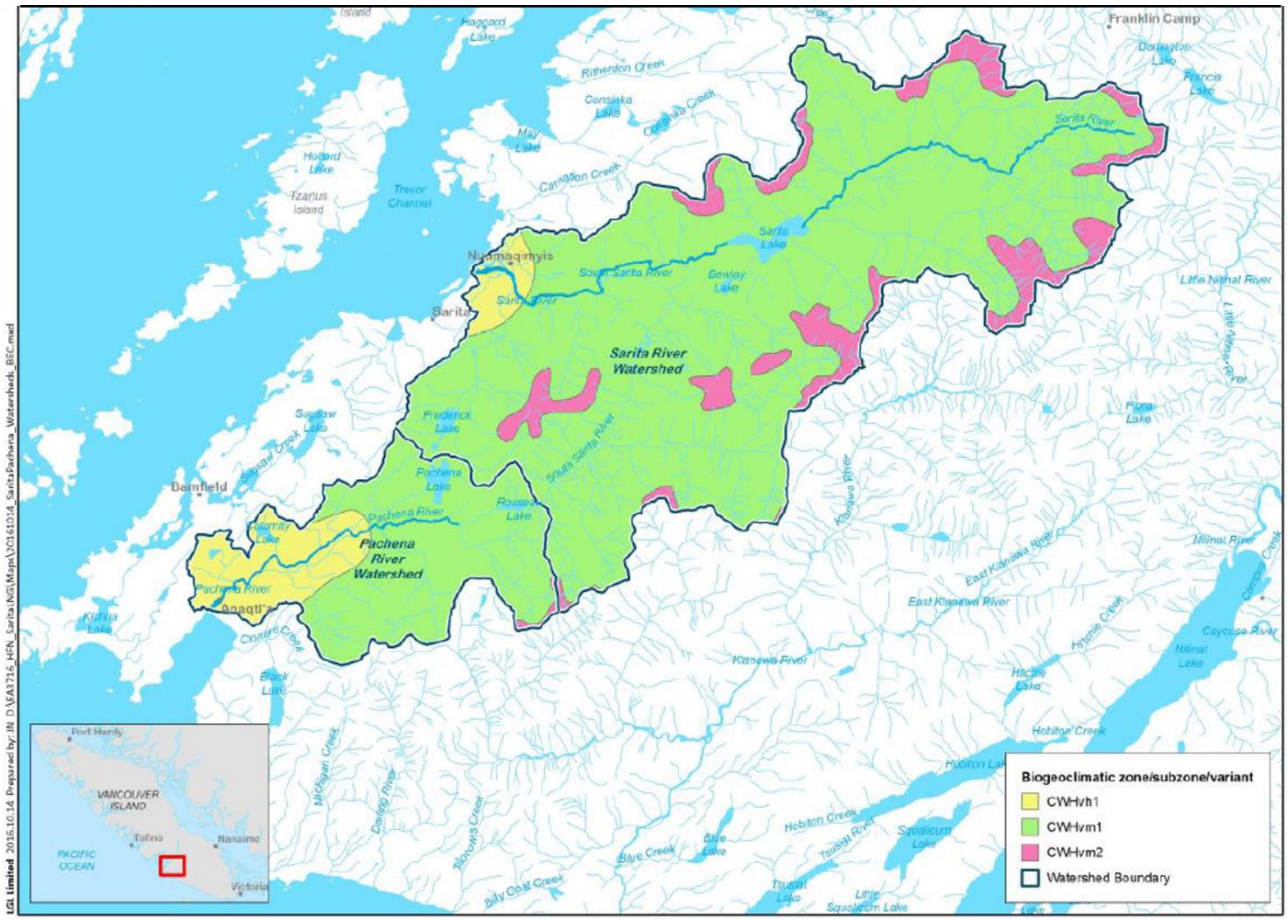


Figure 2 Location of the Sarita and Pachena watersheds in relation to Vancouver Island (lower left inset map) and biogeoclimatic zones, subzones, and variants within the watershed boundaries.

ASSESSMENT AND TREATMENT APPLICATION

Increasing conifer dominance is a key step in riparian restoration, however, it may require a long time and repeat treatment application to create desired outcomes (e.g., functional large woody debris, shade, increased bank stability for improved salmon habitat; Bancroft and Zielke 2002). Depending on the site conditions, regeneration can be challenging, such as in ecosystems that produce dense brush cover. Thus, location of treatment plots must be carefully considered, and methods of vegetation control are often needed.

Riparian Assessment and Layout

A rapid riparian vegetation assessment was conducted in August 2017 to identify suitable areas where added conifers would benefit the streams within the Sarita River Watershed over the long term. This work was expanded in 2018 to include the Pachena River Watershed. Assessments were done by on-the-ground surveys of riparian vegetation types, noting areas with potential for treatment success (see Bancroft et al. 2018 for further details; Figure 3, Figure 4). Areas of interest for treatment application were mapped, flagged, and recorded by layout crews prior to treatment application.



Figure 3 Layout crew (Linnea Bowes, Amber Bowes, and Charlene Wood) going over riparian assessment information on an iPad.

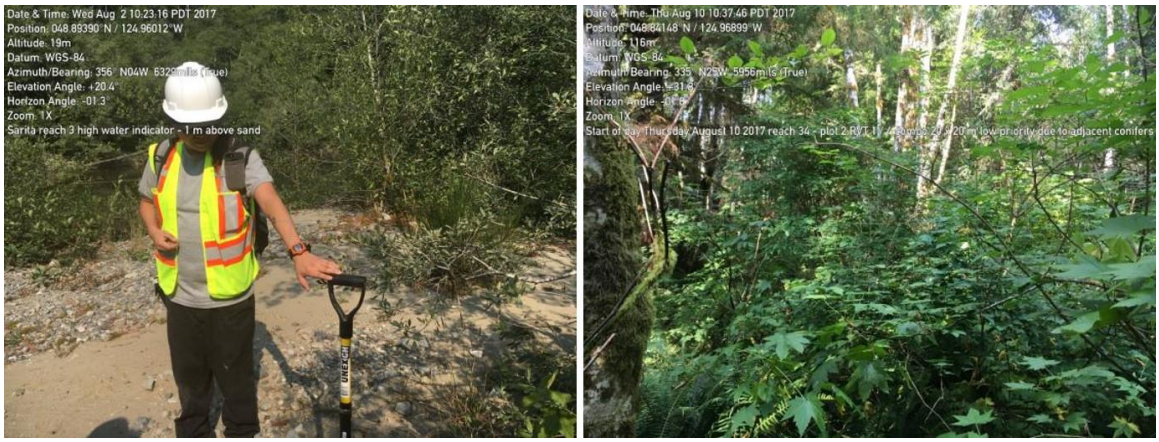


Figure 4 Assessing treatment feasibility and potential for success during riparian assessment. Left: Amber Bowes indicating the height of high water along the Sarita River during flooding events. Right: dense vegetation that is to be left untreated as is adjacent to an area of established larger conifers.

To date, we have treated 0.898 ha (35 polygons) of riparian habitat in the Sarita Watershed (Table 3; Map 1, Map 2, Map 3, Map 4, Map 6) and 0.173 ha (10 polygons) of riparian habitat in the Pachena River Watershed (Table 3; Map 5). Below, we summarize the treatment prescriptions applied in efforts to restore riparian areas in these watersheds.

Brushing

Manual brushing is a common technique for controlling vegetation in British Columbia (Hart and Comeau 1992). Competition from brush (e.g., understorey shrubs) may impede success of planting treatments. Thus, a regime of brushing may be needed to promote survival and growth of newly planted conifer seedlings in treatment areas (Bancroft and Zielke 2002). In addition, brushing in areas where conifers are naturally established in the understorey can help promote conifer release (Bancroft and Zielke 2002), increasing the growth and dominance of conifers in the area.

Brushing was the most common treatment applied during this program to date. Brushing occurred in 45 polygons (1.071 ha) to remove thick understory vegetation, which is necessary to reduce competition with transplanted seedlings (Table 1). All areas treated by brushing were spatially geo-referenced and flagged. Brushing was performed over the entire polygon area.

As of Spring 2019, 10 of 13 Pachena treatment polygons were brushed (0.173 ha; Map 5). Polygons MFS 4, 9, and 13 were deemed to be poor sites for treatment and were not brushed (0.029 ha). In addition, we completed the layout for the Sarita River treatment areas upstream of Sarita Lake (Map 6). Fifty-four polygons (1.798 ha) were flagged as suitable for treatment. Eight of these polygons (0.3 ha) have had an initial brushing treatment completed. Further brushing should be completed mid to late Summer. Brush is expected to re-establish and may require second pass prior to a Fall 2019 planting program.

Table 1 Current brushing summary for each stream area, by watershed. Sarita River treatment polygons are presented in two sections: Sarita River[1] = west (downstream) of Sarita Lake; Sarita River[2] = east (upstream) of Sarita Lake. Details given in Table 3.

Location	No. of polygons	Total polygon area (ha)
Sarita River Watershed	**35**	**0.8975**
Sarita River[1]	2	0.0190
Sarita River[2]	8	0.3005
South Sarita River	3	0.0540
Sabrina Creek	22	0.5240
Pachena River Watershed	**10**	**0.1730**
Pachena River	10	0.1730
Total brushing treatment	**45**	**1.0705**

Girdling

Red alder is a successful pioneer tree species on southern coast of British Columbia. Disturbance adapted and highly tolerant of seasonal flooding, alder is quick to colonize degraded sites. This species also naturally fixes nitrogen, thereby increasing site nutrients. However, to establish conifers on these sites, it is necessary to create a significant opening in the canopy to allow for effective ground-level light penetration (Bancroft and Zielke 2002).

There are several benefits of girdling to produce canopy gaps. Girdling produces a canopy opening slowly overtime (as opposed to tree felling), which allows the understorey stems to acclimate from shade to sun (Bancroft and Zielke 2002). Girdling also produces short-term wildlife trees (snags or high stumps), which provides habitat for deadwood-associated species. Leaving high stumps and girdled stems also prevents accumulation of slash during high flood events (Bancroft and Zielke 2002).

To date, we applied girdling to 26 polygons (0.592 ha), all occurring within the Sarita River Watershed (Table 3). This was done by tagging individual trees to be girdled (i.e., those whose crown is within 5 m of established conifers[2] of any species). The species and height (to the nearest 10 cm) was recorded for each tree that was within the 5 m of the treated stems. All deciduous trees outside of the 5 m radius were retained to provide habitat and structural diversity. Tagged trees (all red alder) were girdled using hand tools after planting completion. This technique results in the gradual death of the area above the girdle over time by severing the cambium to prevent transportation of nutrients.

All previously treated polygons were reassessed for girdling progress. Approximately 20% of the polygons were found to have an unacceptable[3] number of trees improperly or not fully girdled to the extent required to successfully kill the tree. Thus, all polygons were given a second pass to ensure gridling is complete. The girdled trees need to be assessed for effectiveness, treatment plots should also be monitored for potential windthrow of girdled trees, which could disturb transplanted seedlings.

Girdling treatments are planned for Pachena polygons in Fall 2019, after planting is completed. Girdling is also likely to occur in some Sarita River treatment areas that are unsuitable for planting. Because girdling is not expected to produce deciduous die-off for several years post-treatment, follow-up monitoring is recommended for completeness to ensure total deciduous die-off.

[2] Girdling was desirable to maintain a live root mass of an existing alder tree near a streambank. This was done by pruning the alder 1 to 2 m above the ground. Note: alders which are blocking southern exposure are a priority to prune.

[3] We base an "unacceptable" amount on at least 80% of the trees being incorrectly girdled in one polygon.

However, because these dead trees pose an overhead danger to workers and passersby, signage is essential for safety. Thus, signage was posted in all polygons where girdling was applied to inform the potential danger of girdled trees falling at any time (Figure 5). This practice will continue in areas with future girdling treatment application.



Figure 5 Example of signage posted in areas of potential danger during girdling treatment application.

Planting

As of Spring 2019, nearly 1 ha of habitat has been planted with 2,412 conifer seedlings. Thirty polygons (0.765 ha) were planted in the Sarita Watershed and eight polygons (0.158 ha) were planted in the Pachena Watershed (Table 2, Table 3; Figure 6). We planted six areas along Sarita River (2 polygons downstream of Sarita Lake and 4 polygons upstream), three areas along South Sarita River, 21 areas along Sabrina Creek, and eight along Pachena River. Each polygon was planted with either Sitka spruce or western redcedar seedling plugs at a target density of 2,500 sph. Nineteen polygons were planted with western redcedar and 19 polygons were planted with Sitka spruce. In addition, two to four one-gallon cedar stock seedlings were planted in each polygon (Figure 7). The final planting density was 2,841.7 sph for western redcedar and 2,984.4 sph for Sitka spruce (excluding the stems from 1 gal stock).

Fertilizer teabags (RTI Planter Paks) were applied at the roots for all newly transplanted seedlings, including 1 gal stock. Fertilizer was only applied at the initial time of planting when it is most critical to help the plant establish. When properly implemented, this fertilizer eliminates transplant shock by providing nutrient supplements to the seedlings, increasing survival, establishment, and resistance to environmental stress.

Table 2 Current planting summary for the Sarita and Pachena watersheds. Seedling transplant species are abbreviated as: Cw = western redcedar, Ss = Sitka spruce. Density is calculated in stems per hectare (sph). Sarita River[1] = west (downstream) of Sarita Lake; Sarita River[2] = east (upstream) of Sarita Lake Note: 1 gal Cw plants are not included in this table.

Location / Species		No. of polygons	Treated area (ha)	No. of transplants (stems)	Mean transplant density (sph)
Pachena River		**8**	**0.1580**	**428**	**3,361.9**
	Cw	4	0.0630	228	3,707.1
	Ss	4	0.0950	200	3,016.8
Sarita River[1]		**2**	**0.0190**	**50**	**2,613.6**
	Cw	1	0.0110	30	2,727.3
	Ss	1	0.0080	20	2,500.0
Sarita River[2]		**4**	**0.1734**	**340**	**2,089.4**
	Cw	2	0.1085	240	2,608.4
	Ss	2	0.0649	100	1,570.4
South Sarita River		**3**	**0.0540**	**170**	**3,298.0**
	Cw	2	0.0420	120	2,863.6
	Ss	1	0.0120	50	4,166.7
Sabrina Creek		**21**	**0.5190**	**1,424**	**2,872.5**
	Cw	10	0.2730	709	2,549.3
	Ss	11	0.2460	715	3,166.3
Grand total		**38**	**0.9234**	**2,412**	**2,913.0**

Future planting is scheduled to commence in Fall 2019, pending availability of stock. An estimated stock of 4,063 trees is required to plant the 50 remaining polygons mapped upstream of Sarita Lake, assuming a planting density of 2,500 sph. However, it is likely that some of these sites may be deemed unsuitable for planting and could perhaps undergo 100% girdling or be left untreated. An estimated 110 conifer plugs are required to plant the five Pachena River treatment polygons, planting at 2,500 sph. However, monitoring notes suggest that three of these polygons may be poor planting sites, due to thick brush (Table 3). The one remaining area at Sabrina Creek (polygon MFS 23; 0.01 ha) was brushed but is not scheduled for planting due to suboptimal site conditions.



Figure 6 Linnea planting a western redcedar (left) and Amber and Linnea Bowes planting seedlings in a brushed treatment area (right).



Figure 7 Planted western redcedar (1 gal stock), obtained from Western Forest Products (left) and Freegro browse guard provider, John Kendall, with a 1 gal western redcedar (right).

Browse Protection

One of the major factors limiting western redcedar transplant survival on coastal sites is browsing by ungulates (primarily, black-tailed deer; LePage and Banner 2005). In addition, there is an existing population of Roosevelt elk that frequent these riparian sites as well as newly transplanted elk. Thus, browse protection structures are useful to prevent herbivory on newly transplanted conifer seedlings. After planting, Freegro browse protection shelters were installed on most western redcedar seedlings to protect against browsing damage. These were manufactured on Vancouver Island by Cowichan First Nations members, and consist of a mesh tube that was secured around young seedlings by staking (Figure 8, Figure 9, Figure 10). Browse guards were installed on 89% of polygons planted with western redcedar (17 of 19 polygons) and 26% of polygons planted with Sitka spruce (5 of 19 polygons) to prevent damage to young seedlings from deer and newly transplanted elk. However, spruce has not been targeted as ungulate browse and thus, protection of spruce sites is not a priority. The two unprotected cedar polygons (Sarita River MFS 6 & 8) are recommended to be fitted with browse guards in Spring 2020. Rodent damage, improper fertilizer placement, and planting error explained other minor seedling mortality cases.



Figure 8 View from above of a western redcedar protected by a Freegro open mesh browse guard (left) and completed browse guard installation over seedlings planted along Sabrina Creek (right).



Figure 9 Crews organizing and installing Freegro browse protection around newly transplanted vegetation.



Figure 10 Example photo of a site with complete browse protection installed over newly transplanted conifer seedlings.

MONITORING SUMMARY

Over 1 ha of riparian forest has been treated to date, by brushing, girdling, and/or planting. Treatment areas on the Sarita River (downstream of Sarita Lake), along Sabrina Creek, and Pachena Creek have had one full rotation of treatment (e.g., brushing, planting, and girdling). As well there has been follow up brushing, browse shelter recovery, and in-fill planting in areas where there was initial heavy mortality.

Treatment areas were revisited and monitored one-year post-treatment. Some polygons were deemed not ideal for treatment based on flooding/erosion potential, brush persistence, or other site factors and were removed from treatment priority (e.g., Sabrina Creek MFS 13, 14, 16, 17). Several sites showed excellent growth in the first year (e.g., Sabrina Creek MFS 8, 9, 10, 11). Most planted areas (~80% of polygons) had minor mortality, within acceptable limits. Most (85%) of this mortality was due to improper placement of fertilizer t-bag during planting phase, where fertilizer was placed too close to seedling plug, resulting in burnt or disintegrated seedlings. Approximately 10% of stress or mortality can be accredited to poor planting mediums and microsite selection, where the site was too rocky, or placement is within drip line of coniferous stands. A final 5% of mortality is attributed to wildlife disturbance, either knocked over, stepped on, or gridled by voles or rodents. Planting with fertilizer will require more diligent application during planting phase of future treatment areas to ensure higher rate of success.

Brush is expected to re-establish in many of the treatment polygons and may require second or additional passes to ensure treatment success. During follow-up monitoring, notes were made on polygons that require a second pass of brushing. Likewise, girdling must be monitored for completeness to ensure total deciduous die-off and may require a second pass if initial girdling is deemed ineffective.

The Freegro browse guard system had excellent results after the first year of growth. Less than 5% of sheltered tree seedlings had signs of browse. All shelters were checked and tightened after first year of planting. Shelters were recovered from any dead seedlings and cleaned and stored for next use. Currently, there are 900 stakes and 2,900 shelters in storage for future treatment application.

Recommendations

The following recommendations are made for future riparian renewal work:

1. Assess transplant growth and recover or tighten shelters during early Spring 2020, before brush begins to flush. Shelters will be clean from rain and snow events over the Winter season.
2. Conduct assessments for additional brushing needs in mid Summer when vegetation is in full bloom. Complete brushing treatments late Summer, before vegetation begins to store reserves for Winter.
3. Continue to treat mapped areas along the Sarita River upstream of Sarita Lake. Brushing, planting, and girdling with follow-up monitoring should continue at these sites.
4. Designate demonstration sites for riparian restoration and cedar production for cultural use. Sabrina Creek MFS 8, 9, and 10 are sizable polygons that display the treatment phases well. Growth on these sites is also very good for both cedar and spruce.

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APPENDICES

Appendix A: Treatment Application and Layout Notes

Table 3 Notes for treatment areas in the Sarita and Pachena watersheds. Proposed no. of stems was based on a target planting density of 2,500 stems per hectare (sph). Note: 1 gal Cw plants are not included in density estimates and calculations. Abbreviations are as follows: Sp.= transplant species, Cw = western redcedar, Ss = Sitka spruce, Y = yes, NA = not applicable, FSZ = Fisheries Sensitive Zone. Sarita River[1] = west (downstream) of Sarita Lake; Sarita River[2] = east (upstream) of Sarita Lake. Sheltered indicates that browse guard was applied.

Location	Polygon unit	Area (ha)	Brushed	Planted	Girdled	Sheltered	Sp.	Proposed no. of stems	No. of stems planted	Transplant density (sph)	Notes
Sarita River[1]	SR 1	0.0210					NA				Not treated. Site not ideal for treatment.
Sarita River[1]	SR 2	0.0200					NA				Not treated. Site not ideal for treatment.
Sarita River[1]	SR 3	0.0040					NA				Not treated. Site not ideal for treatment.
Sarita River[1]	SR 4	0.0110	Y	Y	Y	Y	Cw	28	30	2,727.3	20% mortality after first year from improper fertilizer placement- site was restocked with Ss in Fall 2018 to mitigate high risk of continued mortality.
Sarita River[1]	SR 5	0.0080	Y	Y	Y	Y	Ss	20	20	2,500.0	70–80% mortality after first year from improper fertilizer placement- site was replanted 100% with Ss in Fall 2018.
Sarita River[2]	MFS 1	0.0747					NA	187			Not treated. Plant to higher microsites and avoid water receiving depressions.
Sarita River[2]	MFS 2	0.1694					NA	423			Not treated. Avoid planting saturated soils in center of polygon.
Sarita River[2]	MFS 3	0.1132					NA	283			Not treated.
Sarita River[2]	MFS 4	0.0688	Y				NA	172			
Sarita River[2]	MFS 5	0.0369	Y	Y			Ss	92	50	1,355.0	
Sarita River[2]	MFS 6	0.0331	Y	Y			Cw	83	120	3,625.4	Plans to apply shelters in Spring 2020.
Sarita River[2]	MFS 7	0.0280	Y	Y			Ss	70	50	1,785.7	Rocky patched throughout polygon should be avoided when planting.
Sarita River[2]	MFS 8	0.0754	Y	Y			Cw	189	120	1,591.5	Plans to apply shelters in Spring 2020.
Sarita River[2]	MFS 9	0.0470					NA	118			Not treated.
Sarita River[2]	MFS 10	0.0432					NA	108			Not treated. Heavily mounded site- plant to higher microsites and avoid depressions.
Sarita River[2]	MFS 11	0.0232					NA	58			Not treated. This site has an abundance of LWD- obstacle plant and keep to higher microsites.
Sarita River[2]	MFS 12	0.0370					NA	93			Not treated.
Sarita River[2]	MFS 13	0.0562					NA	141			Not treated.
Sarita River[2]	MFS 14	0.0558					NA	140			Not treated.
Sarita River[2]	MFS 15	0.0303					NA	76			Not treated. This site has an abundance of LWD- obstacle plant and keep to higher microsites.

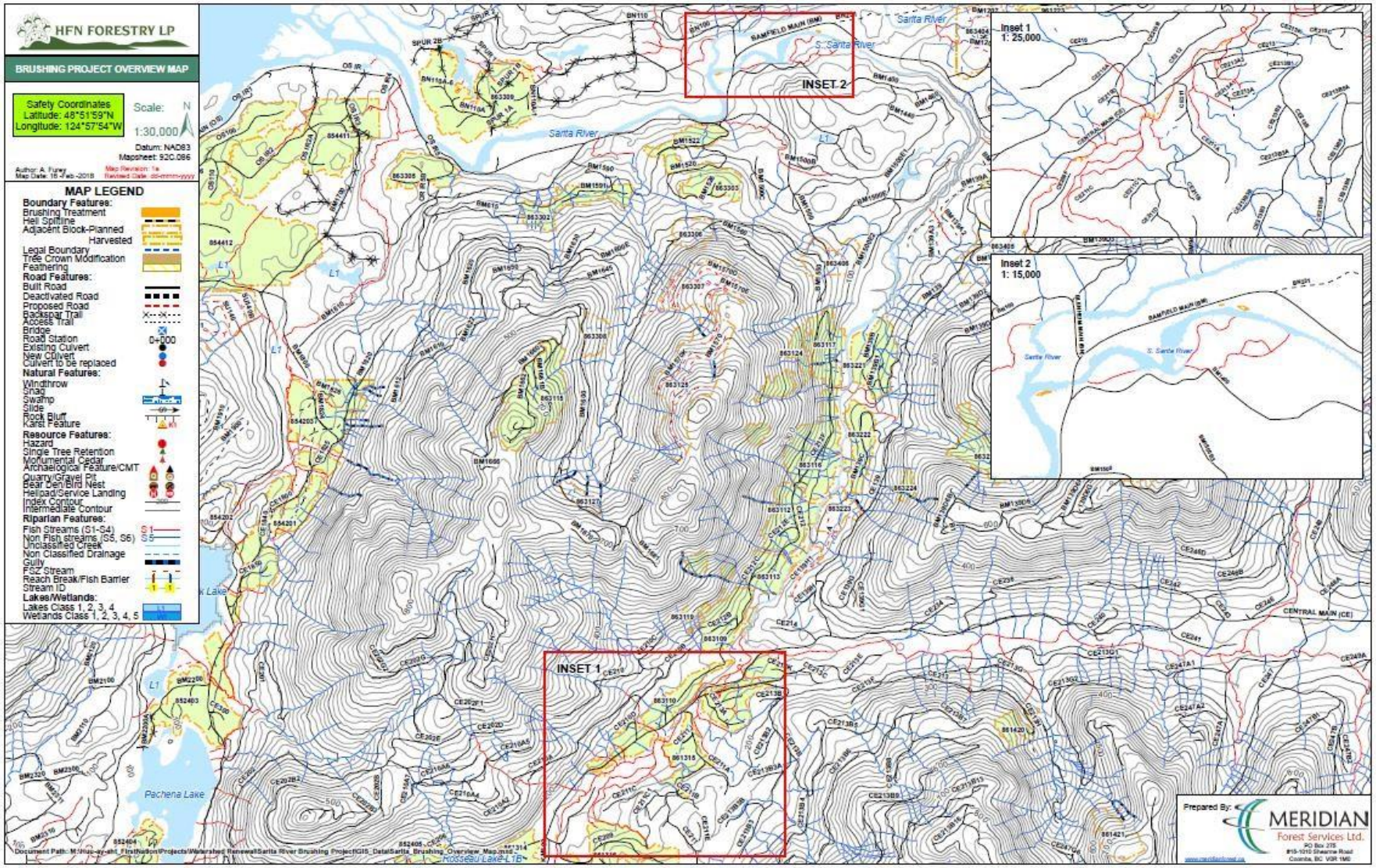
Location	Polygon unit	Area (ha)	Brushed	Planted	Girdled	Sheltered	Sp.	Proposed no. of stems	No. of stems planted	Transplant density (sph)	Notes
Sarita River[2]	MFS 16	0.0374					NA	94			Not treated.
Sarita River[2]	MFS 17	0.0219					NA	55			Not treated. Avoid planting in saturated soils around edge of polygon.
Sarita River[2]	MFS 18	0.0566					NA	142			Not treated.
Sarita River[2]	MFS 19	0.0082					NA	21			Not treated.
Sarita River[2]	MFS 20	0.0121					NA	30			Not treated.
Sarita River[2]	MFS 21	0.0177					NA	44			Not treated. Soils are very sandy closer to riverbank.
Sarita River[2]	MFS 22	0.0216					NA	54			Not treated. Terrain is slightly mounded- plant on raised microsites and avoid water receiving depressions.
Sarita River[2]	MFS 23	0.0068					NA	17			Not treated.
Sarita River[2]	MFS 24	0.0276					NA	69			Not treated. Dense Himalayan blackberry (*Rubus armeniacus*).
Sarita River[2]	MFS 25	0.0404					NA	101			Not treated.
Sarita River[2]	MFS 26	0.0564					NA	141			Not treated. FSZ adjacent- not high priority for treatment.
Sarita River[2]	MFS 27	0.0554					NA	139			Not treated. FSZ adjacent- not high priority for treatment.
Sarita River[2]	MFS 28	0.0294					NA	74			Not treated. FSZ adjacent- not high priority for treatment.
Sarita River[2]	MFS 29	0.0179					NA	45			Not treated.
Sarita River[2]	MFS 30	0.0528					NA	132			Not treated.
Sarita River[2]	MFS 31	0.0438					NA	110			Not treated.
Sarita River[2]	MFS 32	0.0269	Y				NA	67			FSZ adjacent- not high priority for treatment.
Sarita River[2]	MFS 33	0.0230	Y				NA	58			
Sarita River[2]	MFS 34	0.0084	Y				NA	21			
Sarita River[2]	MFS 35	0.0099					NA	25			Not treated.
Sarita River[2]	MFS 36	0.0115					NA	29			Not treated.
Sarita River[2]	MFS 37	0.0127					NA	32			Not treated.
Sarita River[2]	MFS 38	0.0087					NA	22			Not treated.
Sarita River[2]	MFS 39	0.0251					NA	63			Not treated.
Sarita River[2]	MFS 40	0.0174					NA	44			Not treated.
Sarita River[2]	MFS 41	0.0216					NA	54			Not treated.
Sarita River[2]	MFS 45	0.0184					NA	46			Not treated.
Sarita River[2]	MFS 46	0.0186					NA	47			Not treated.
Sarita River[2]	MFS 47	0.0146					NA	37			Not treated.

Location	Polygon unit	Area (ha)	Brushed	Planted	Girdled	Sheltered	Sp.	Proposed no. of stems	No. of stems planted	Transplant density (sph)	Notes
Sarita River[2]	MFS 48	0.0107					NA	27			Not treated.
Sarita River[2]	MFS 49	0.0109					NA	27			Not treated.
Sarita River[2]	MFS 50	0.0194					NA	49			Not treated.
Sarita River[2]	MFS 51	0.0062					NA	16			Not treated.
Sarita River[2]	MFS 52	0.0168					NA	42			Not treated.
Sarita River[2]	MFS 53	0.0274					NA	69			Not treated.
Sarita River[2]	MFS 54	0.0272					NA	68			Not treated.
Sarita River[2]	MFS 55	0.0240					NA	60			Not treated.
Sarita River[2]	MFS 56	0.0189					NA	47			Not treated. Rubber hosing was noted during layout- must be cleared prior to planting.
Sarita River[2]	MFS 57	0.0222					NA	56			Not treated.
South Sarita River	SS 1	0.0200	Y	Y	Y	Y	Cw	50	60	3,000.0	2 shelters broken by wildlife. Rocky planting medium causing stress. Less than 10% mortality.
South Sarita River	SS 2	0.0120	Y	Y	Y		Ss	30	50	4,166.7	10 cm growth in first year. Trees are vigorous.
South Sarita River	SS 3	0.0220	Y	Y	Y	Y	Cw	55	60	2,727.3	5 cm average growth after first year. Minor stress.
Sabrina Creek	MFS 1	0.0140	Y	Y	Y		Ss	35	40	2,857.1	15–20% mortality from fertilizer placement and girdled collars. Remaining stock is flourishing.
Sabrina Creek	MFS 2	0.0190	Y	Y	Y	Y	Cw	48	40	2,105.3	Less than 10% mortality from fertilizer placement. Good growth post-Winter season.
Sabrina Creek	MFS 3	0.0120	Y	Y	Y	Y	Ss	30	39	3,250.0	30–40% mortality from improper fertilizer placement and microsite selection after first year.
Sabrina Creek	MFS 4	0.0110	Y	Y	Y	Y	Cw	28	30	2,727.3	15–20% mortality from fertilizer and 10% stressed with dead laterals after first year. Rest of stock shows 5+ cm growth.
Sabrina Creek	MFS 5	0.0480	Y	Y	Y	Y	Ss	120	100	2,083.3	
Sabrina Creek	MFS 5 A	0.0110	Y	Y	Y		Ss	28	46	4,181.8	Good growth and colour. Salmonberry is expected to come back thick. Second brushing pass required.
Sabrina Creek	MFS 6	0.0480	Y	Y	Y		Ss	120	120	2,500.0	
Sabrina Creek	MFS 7	0.0320	Y	Y	Y	Y	Cw	80	60	1,875.0	
Sabrina Creek	MFS 8	0.0540	Y	Y	Y	Y	Cw	135	149	2,759.3	Leader growth 5+ cm. 10% mortality from fertilizer placement.
Sabrina Creek	MFS 9	0.0520	Y	Y	Y	Y	Cw	130	197	3,788.5	Good growth- possible demonstration site with MFS 8 and 10.
Sabrina Creek	MFS 10	0.0240	Y	Y	Y		Ss	60	70	2,916.7	Excellent growth in first year. Less than 10% mortality from fertilizer placement. 60–67 cm trees.
Sabrina Creek	MFS 11	0.0270	Y	Y	Y	Y	Cw	68	63	2,333.3	Excellent growth in first year. No mortality. Second brushing pass required.
Sabrina Creek	MFS 12	0.0210	Y	Y	Y		Ss	53	60	2,857.1	

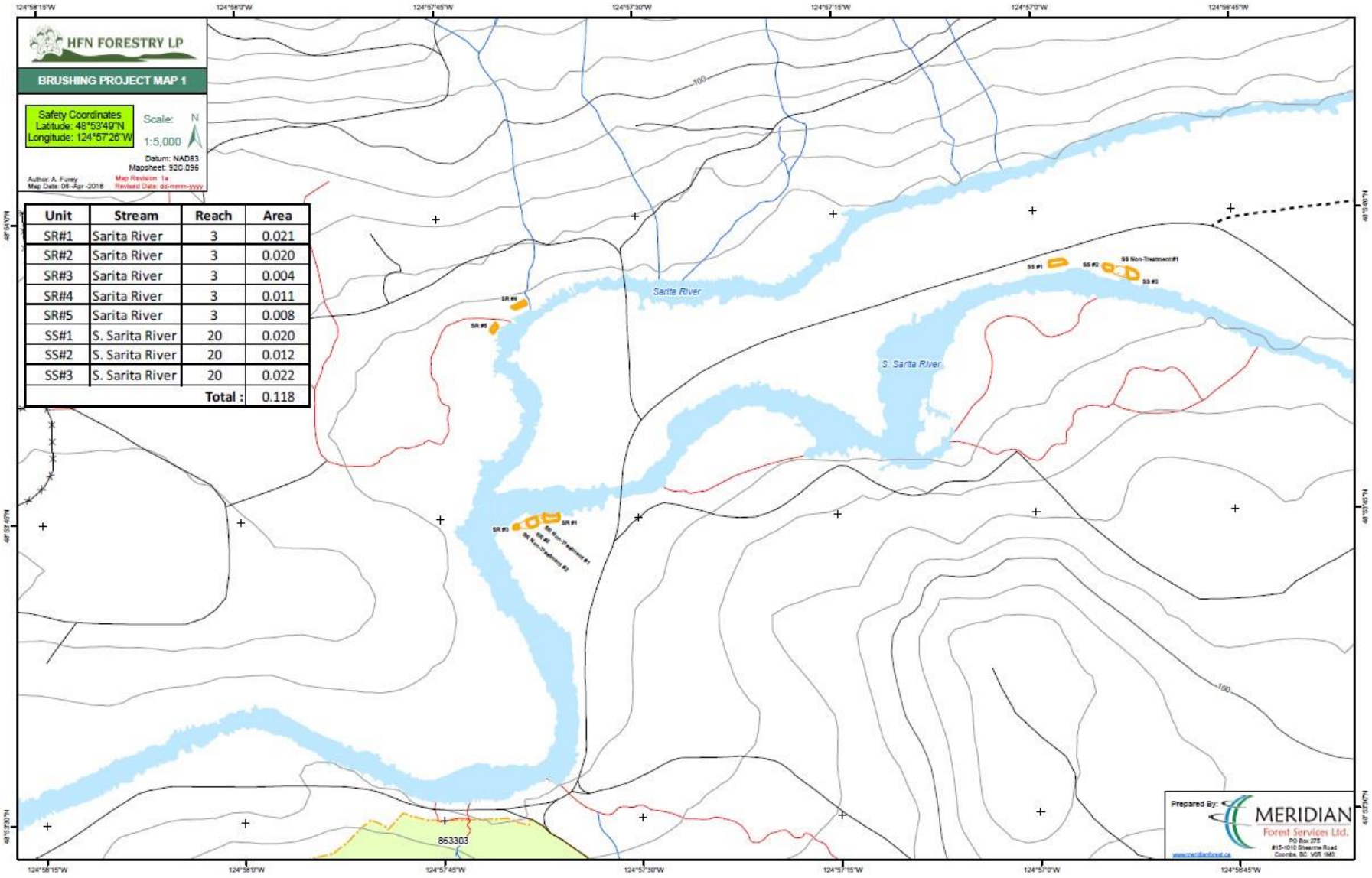
Location	Polygon unit	Area (ha)	Brushed	Planted	Girdled	Sheltered	Sp.	Proposed no. of stems	No. of stems planted	Transplant density (sph)	Notes
Sabrina Creek	MFS 13	0.0370					NA	93			Not treated. Site not ideal for treatment.
Sabrina Creek	MFS 14	0.0170					NA	43			Not treated. Site not ideal for treatment.
Sabrina Creek	MFS 15	0.0340	Y	Y	Y	Y	Cw	85	50	1,470.6	Less than 10% mortality from fertilizer placement. Will require brushing in Summer 2019. Second brushing pass required.
Sabrina Creek	MFS 16	0.0180					NA	45			Not treated. Site not ideal for treatment.
Sabrina Creek	MFS 17	0.0060					NA	15			Not treated. Site not ideal for treatment.
Sabrina Creek	MFS 18	0.0120	Y	Y	Y		Ss	30	41	3,416.7	
Sabrina Creek	MFS 19	0.0090	Y	Y	Y	Y	Cw	23	30	3,333.3	
Sabrina Creek	MFS 20	0.0140	Y	Y	Y	Y	Ss	35	54	3,857.1	No mortality noted. Some stress on poor micro sites. Ss over all show good growth.
Sabrina Creek	MFS 21	0.0200	Y	Y	Y	Y	Cw	50	54	2,700.0	Trees have good recovery from Winter- good colour.
Sabrina Creek	MFS 22	0.0220	Y	Y	Y	Y	Ss	55	75	3,409.1	20–30% mortality from poor planting and fertilizer placement. Surviving trees are starting to harden and show good colour and leader growth.
Sabrina Creek	MFS 23	0.0050	Y				NA	13			Site not ideal for planting treatment.
Sabrina Creek	MFS 24	0.0200	Y	Y	Y		Ss	50	70	3,500.0	
Sabrina Creek	MFS 25	0.0150	Y	Y	Y	Y	Cw	38	36	2,400.0	
Pachena	MFS 1	0.0170	Y	Y		Y	Cw	43	105	6,176.5	
Pachena	MFS 2	0.0380	Y	Y			Ss	95	60	1,578.9	
Pachena	MFS 3	0.0050	Y				NA	13			Brush grew back too thick to plant after initial brushing treatment. Second brushing pass required.
Pachena	MFS 4	0.0060					NA	15			Not treated.
Pachena	MFS 5	0.0090	Y	Y		Y	Cw	23	33	3,666.7	
Pachena	MFS 6	0.0210	Y	Y			Ss	53	41	1,952.4	
Pachena	MFS 7	0.0210	Y	Y		Y	Cw	53	43	2,047.6	
Pachena	MFS 8	0.0280	Y	Y			Ss	70	43	1,535.7	Brush too thick to plant full complement of seedlings. Second brushing pass required.
Pachena	MFS 9	0.0050					NA	13			Not treated. Not brushed- poor planting site.
Pachena	MFS 10	0.0100	Y				NA	25			Brush too thick to plant. Second brushing pass required.
Pachena	MFS 11	0.0160	Y	Y		Y	Cw	40	47	2,937.5	
Pachena	MFS 12	0.0080	Y	Y			Ss	20	56	7,000.0	Second brushing pass required.
Pachena	MFS 13	0.0180					NA	45			Not treated. Brush too thick to plant.

Appendix B: Maps of Riparian Renewal Treatment Areas

Map 1 Sarita treatment area overview map.

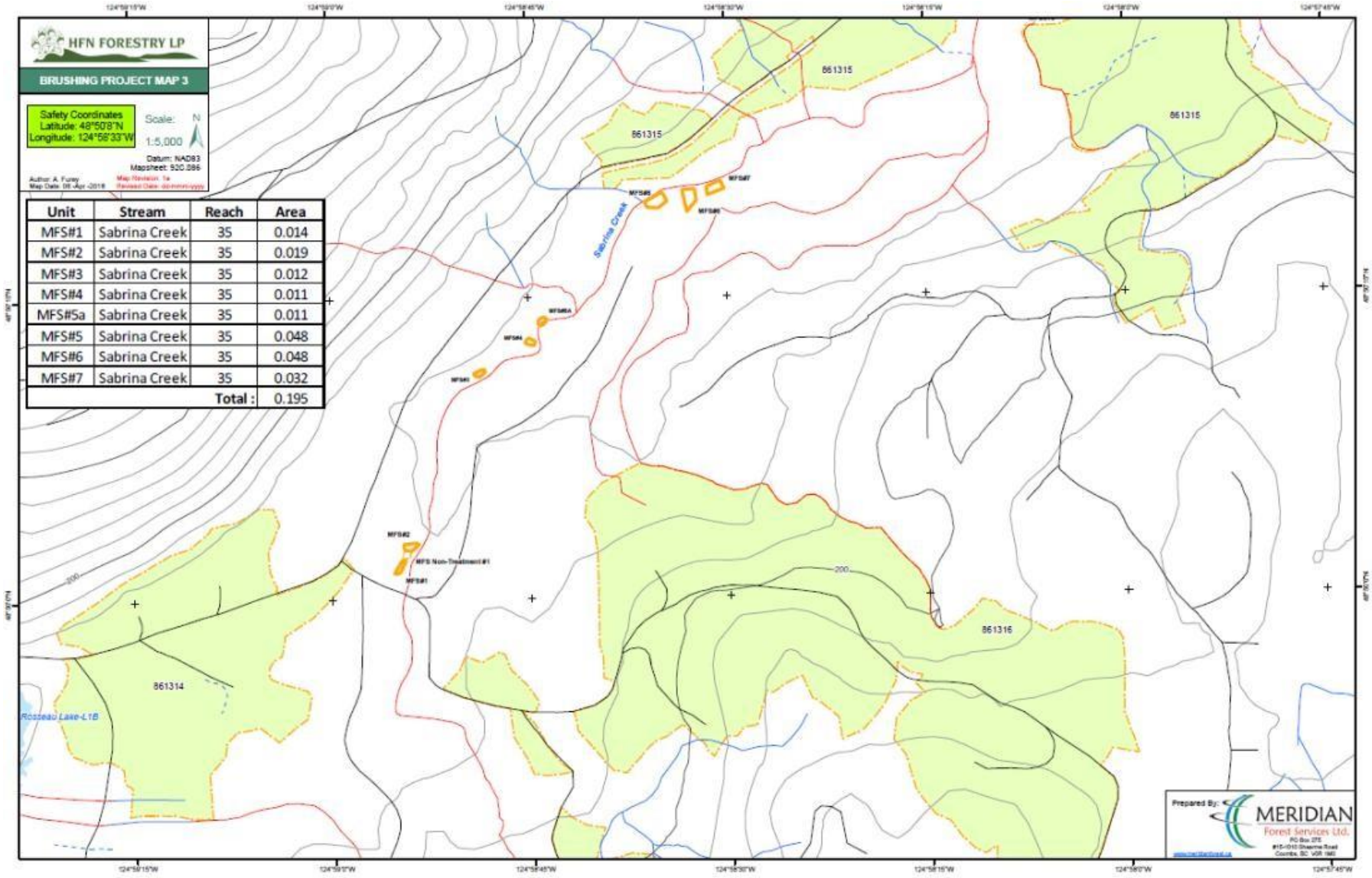


Map 2 Treatment areas marked by layout crews along the Sarita River (downstream of Sarita Lake) and South Sarita River. Polygon units SR#4, SR#5, SS#1, SS#2, and SS#3 were brushed, planted, and girdled. Polygons SR#1, SR#2, and SR#3 are shown, but were not treated as they were deemed unsuitable. Details found in Table 3.

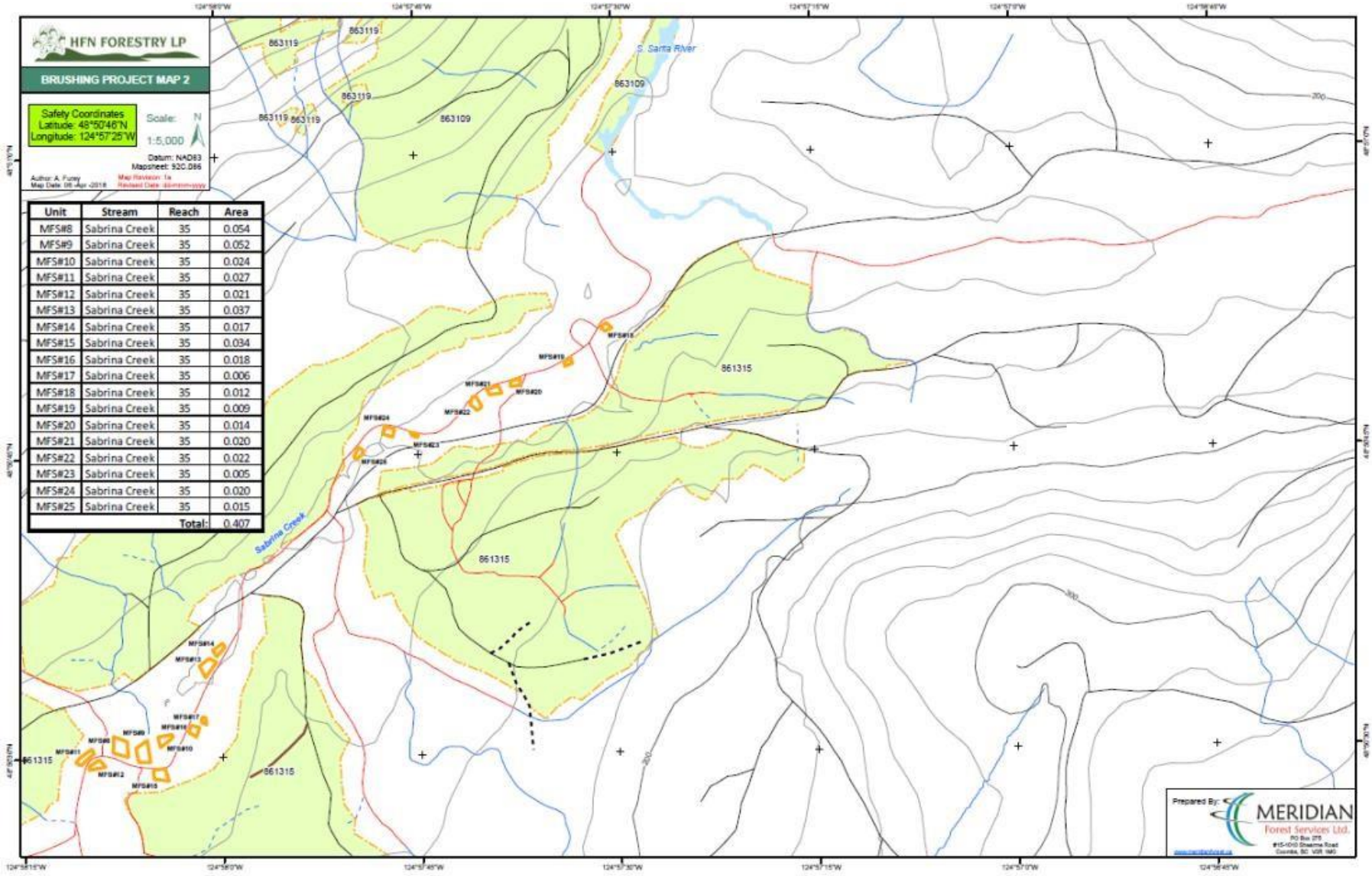


Unit	Stream	Reach	Area
SR#1	Sarita River	3	0.021
SR#2	Sarita River	3	0.020
SR#3	Sarita River	3	0.004
SR#4	Sarita River	3	0.011
SR#5	Sarita River	3	0.008
SS#1	S. Sarita River	20	0.020
SS#2	S. Sarita River	20	0.012
SS#3	S. Sarita River	20	0.022
		Total :	0.118

Map 3 Treatment areas marked by layout crews along Sabrina Creek (map 1 of 2). These eight polygons were brushed, planted, and girdled. Details of applied treatments can be found in Table 3.

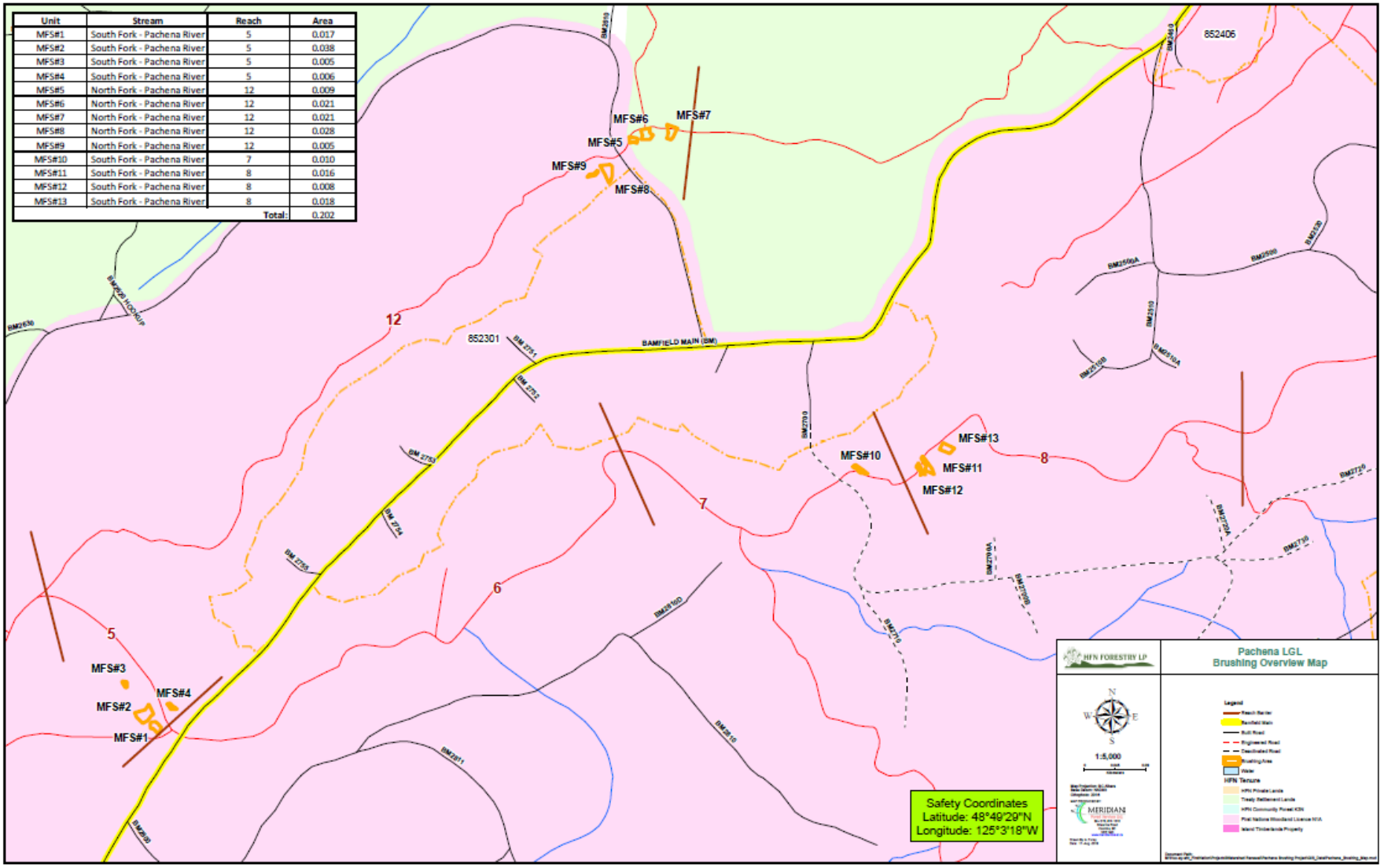


Map 4 Treatment areas marked by layout crews along Sabrina Creek (map 2 of 2). Fourteen of these 18 polygons were treated (MFS 13, 14, 16, and 17 were deemed unsuitable). Details of applied treatments can be found in Table 3.



Unit	Stream	Reach	Area
MFS#8	Sabrina Creek	35	0.054
MFS#9	Sabrina Creek	35	0.052
MFS#10	Sabrina Creek	35	0.024
MFS#11	Sabrina Creek	35	0.027
MFS#12	Sabrina Creek	35	0.021
MFS#13	Sabrina Creek	35	0.037
MFS#14	Sabrina Creek	35	0.017
MFS#15	Sabrina Creek	35	0.034
MFS#16	Sabrina Creek	35	0.018
MFS#17	Sabrina Creek	35	0.006
MFS#18	Sabrina Creek	35	0.012
MFS#19	Sabrina Creek	35	0.009
MFS#20	Sabrina Creek	35	0.014
MFS#21	Sabrina Creek	35	0.020
MFS#22	Sabrina Creek	35	0.022
MFS#23	Sabrina Creek	35	0.005
MFS#24	Sabrina Creek	35	0.020
MFS#25	Sabrina Creek	35	0.015
		Total:	0.407

Map 5 Treatment areas marked by layout crews in the Pachena River Watershed. Ten of the 13 polygons were brushed (MFS 4, 9, and 13 were not treated). Eight of these ten polygons were planted after brushing treatment was applied. Details found in Table 3.



Unit	Stream	Reach	Area
MFS#1	South Fork - Pachena River	5	0.017
MFS#2	South Fork - Pachena River	5	0.038
MFS#3	South Fork - Pachena River	5	0.005
MFS#4	South Fork - Pachena River	5	0.006
MFS#5	North Fork - Pachena River	12	0.009
MFS#6	North Fork - Pachena River	12	0.021
MFS#7	North Fork - Pachena River	12	0.021
MFS#8	North Fork - Pachena River	12	0.028
MFS#9	North Fork - Pachena River	12	0.005
MFS#10	South Fork - Pachena River	7	0.010
MFS#11	South Fork - Pachena River	8	0.016
MFS#12	South Fork - Pachena River	8	0.008
MFS#13	South Fork - Pachena River	8	0.018
		Total:	0.202

Map 6 Sarita River treatment areas north of Sarita Lake. Four of these polygons were brushed and planted, while an additional four were brushed, as of Summer 2019. Details found in Table 3.

