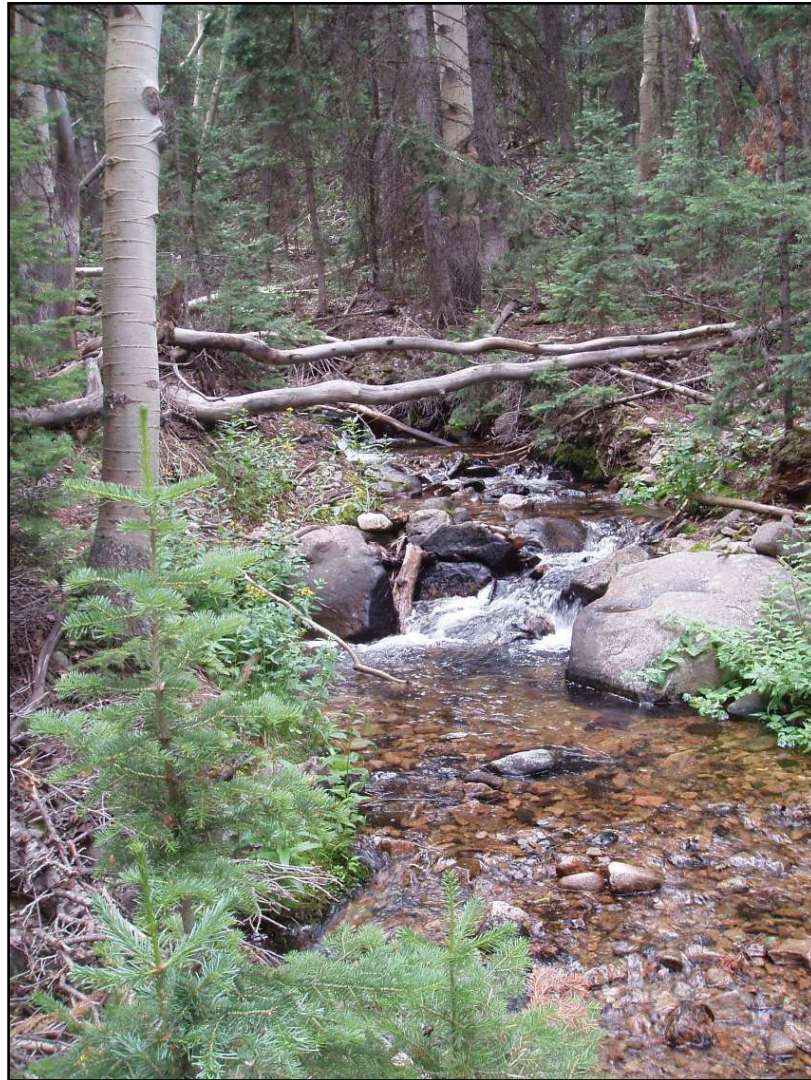


Brush Creek
Aquatic Habitat Enhancement Project
Elk Mountain Ranch
Carbon County, WY



Prepared by



FIN-UP Habitat Consultants, Inc.

J. Peter Gallagher
220 Illinois Ave
Manitou Springs, CO 80829
(719) 685-9768 (Office)
(719) 332-2550 (Cell)

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Elk Mountain lies on the watershed divide between the Medicine Bow River and Pass Creek watersheds, two major tributaries of the North Platte River in south central Wyoming. Within the Elk Mountain Ranch there are four perennial streams and over 25 ponds and lakes. The headwaters of two major streams, Rattlesnake and Halleck Creeks, are found on the ranch. Two other lesser headwater streams, Brush Creek and Johnson Creek, also originate on the ranch.

A rapid, landscape scale assessment of aquatic habitat conditions was conducted by Land Stewardship Associates, LLC and FIN-UP Habitat Consultants, Inc. in August and September, 2006. The results of this assessment are contained in the documents *Elk Mountain Ranch - NATURAL RESOURCE MASTER PLAN - PARTS 1& 2* (LSA, LLC, 2006). The 2006 aquatic assessment identified limiting factors and potential restoration projects for fisheries on the streams within the Elk Mountain Ranch, including Brush Creek. During the course of this assessment, Brush Creek Reach 2 was identified as presenting an opportunity in the drainage for aquatic habitat manipulation and enhancement to reestablish a brook or brown trout fishery in the headwaters.

In July, 2007, FIN-UP, Inc. returned to the Elk Mountain Ranch to collect additional data to develop a detailed habitat enhancement plan for Reach 2 on Brush Creek, with the primary goal of increasing pool depth and complexity, providing enhanced "pocket water" cover habitats in the riffles, and addressing the road/stream interactions in the project reach. This document will describe a recommended treatment plan for addressing the habitat and bank stability issues in the study reach.

Project Reach Descriptions and Existing Conditions:

Brush Creek begins near the lower south summit of Elk Mountain and flows to the southwest, down through a steep gorge for more than one thousand feet. Emerging from this gorge, the stream flows across a large alluvial plain, exiting the ranch at an elevation of about 7,800 ft. The stream continues flowing to the south and west through a broad valley to a confluence with Pass Creek. Brush Creek exhibits no surface flow where it flows across the alluvial plain during the late summer and fall. This seasonal barrier to migration and resulting fragmentation of aquatic habitat most likely severely limits Brush Creek to support a sustainable fishery on the Elk Mountain Ranch. Several miles below the ranch, a viable, self-sustaining brook and rainbow trout fishery has been documented by the Wyoming Department of Fish and Game.

The representative 1,000 ft. segment was located in the lower part of the study reach. The habitat inventory began at the fence crossing the stream, and continued upstream, past a road/trail crossing, and into the steep canyon above.

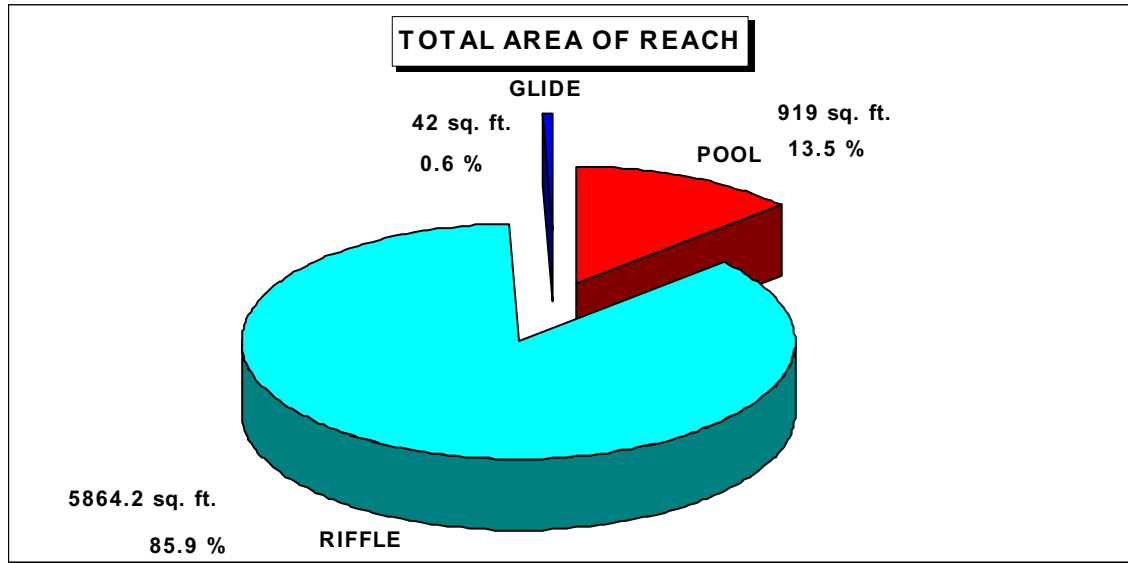


Chart 1: Distribution of Pool, Riffle, & Glide Habitats in Reach 2 on Brush Creek.

A total of thirty-four separate meso-habitats were identified in the study segment. These were composed of sixteen pools, seventeen riffles, and one glide habitat (Chart 1). The average width of the stream was 6.5 feet and the average depth was 0.4 feet. Channel substrate was predominately gravel and cobble, with considerable accumulations of boulders. Sand and silt was limited in all habitat types, and in-filling of depositional areas such as the bottom of pools was relatively insignificant. Large wood was present in the channel to a degree, with 45 individual pieces counted during the survey. Large wood provided important velocity shelter and cover, but was not the principal contributor to habitat creation and scour (Photo 1). Stream banks were generally vegetated and stable throughout the reach, and the bank rock particle size (BRC) consisted mostly of larger cobble providing good armoring of the banks. Two hundred and sixty feet of active eroding banks were measured in the study segment, and were primarily the result of erosion from high run-off flows.



Photo 1: Typical Riffle on Brush Creek.

Pools were principally formed by water plunging over boulders or other large obstructions in the channel. Pool habitats comprised approximately 14% of the total wetted area of the study segment. The average depth of all of the pools measured was 0.64 ft., with maximum pool depths ranging from 0.7 to nearly 2 feet. Residual pool depth (RPD) was found to range from 0 to 1.7 feet, with an average of 0.8 feet throughout the reach. RPD and maximum pool depth, upon closer inspection, were found to be better than expected in the reach, and may provide some over-wintering habitat for brook trout at this elevation.

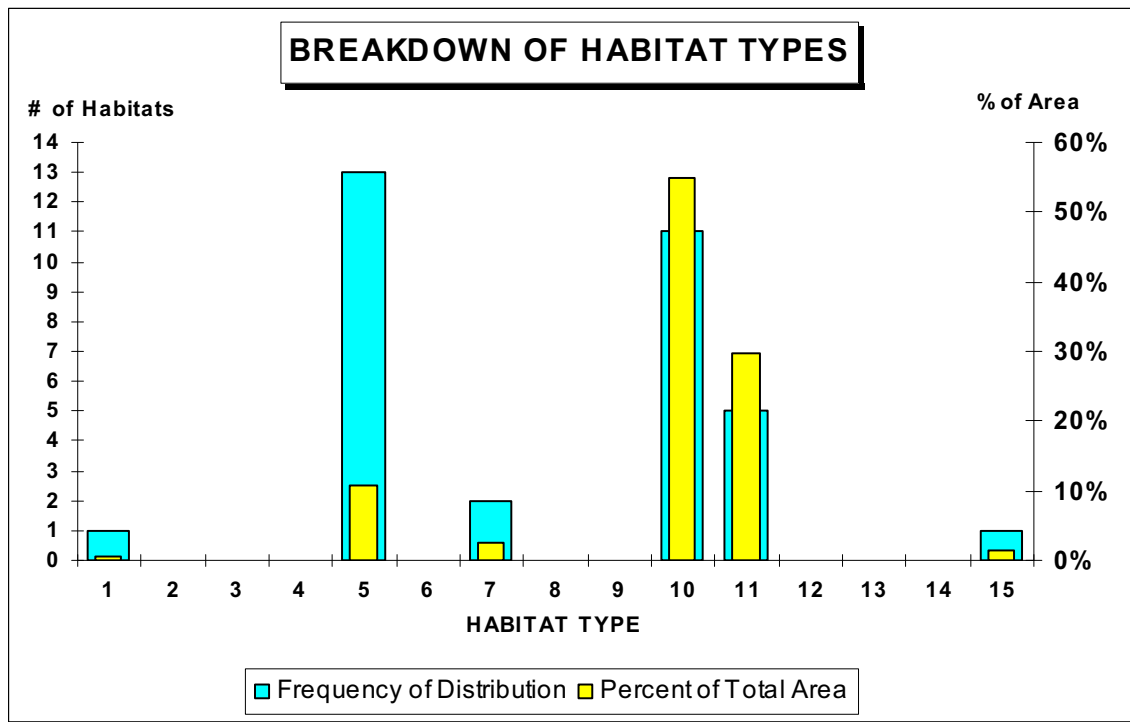


Chart 2: Percentage distribution of Pool, Riffle, & Glide Habitat forms in Reach 2.

High-gradient, pocket water dominated cobble and boulder riffles were the most abundant habitat type, in terms of both numbers and area, in the study segment, comprising more than 86% of the wetted area (Chart 2). These riffles typically dominate A and B channel types, and depending on depth and substrate structure, may provide important holding and feeding habitats for trout, as well as critical habitat for benthic macro-invertebrates and other aquatic organisms. The average depth of these riffles was 0.23 feet in the study segment. Pocket water cover for trout was observed in many of the riffles, and comprised 1.5% of the wetted perimeter of these habitats. Riffles in the study segment did appear to provide adequate spawning habitat for trout.

One glide was observed in the reach. Glides are not typically encountered in A and steeper B channels, unless they are due to some form of disturbance. This glide was observed in the area immediately upstream of the trail crossing the creek. Glide habitat accounted for less than 1% of the total wetted area of the reach.

The quantity of suitable cover in the Brush Creek study segment was very limited (Chart 3), accounting for 1% of the total wetted area of the channel. Cover was principally composed of pocket water in-channel cover. Pool cover, an important metric for determining over-wintering capacity in the study segment, was present in the study segment, but accounted for less than 1% of the wetted area of the pool habitats. It is interesting to note that the best pools in the study reach occurred in the upstream half of the segment, above the road/trail crossing, and it may be that cover estimates are slightly understated in the reach due to the inclusion of exceptionally poor habitat downstream of the crossing.

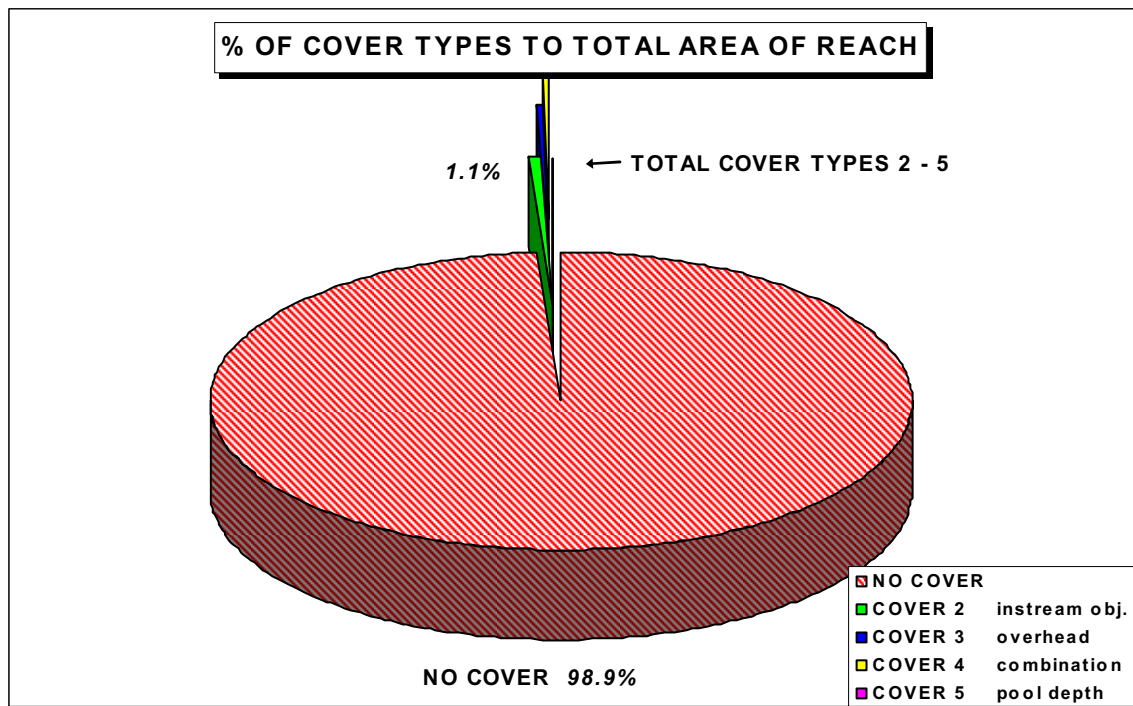


Chart 3: Percentage of Cover Types within Reach 2 on Brush Creek.

The habitat data collected in this segment suggests that Reach 2 could be enhanced to establish a brook or brown trout fishery. Pool residual depth and cover appear to be limiting factors in the reach. It may be desirable to enhance pool and pocket water habitats in the reach by removing armor (boulder and cobble) from the bottom of existing pools to enhance scour, improve RPD, and deepen these habitats. This work can be done by back-hoe, small excavator, or by hand. Additionally, trees may be cross-felled into the channel to create log and woody debris dam habitats. This large wood would also add roughness to the channel, and help dissipate energy from high flows during spring snow melt. Upon completion of the habitat enhancements, brook or brown trout could be stocked into the reach using tanks mounted on ATV's to transport the fish from an off-loading area near the Ranch Operations HQ to the stream reach.

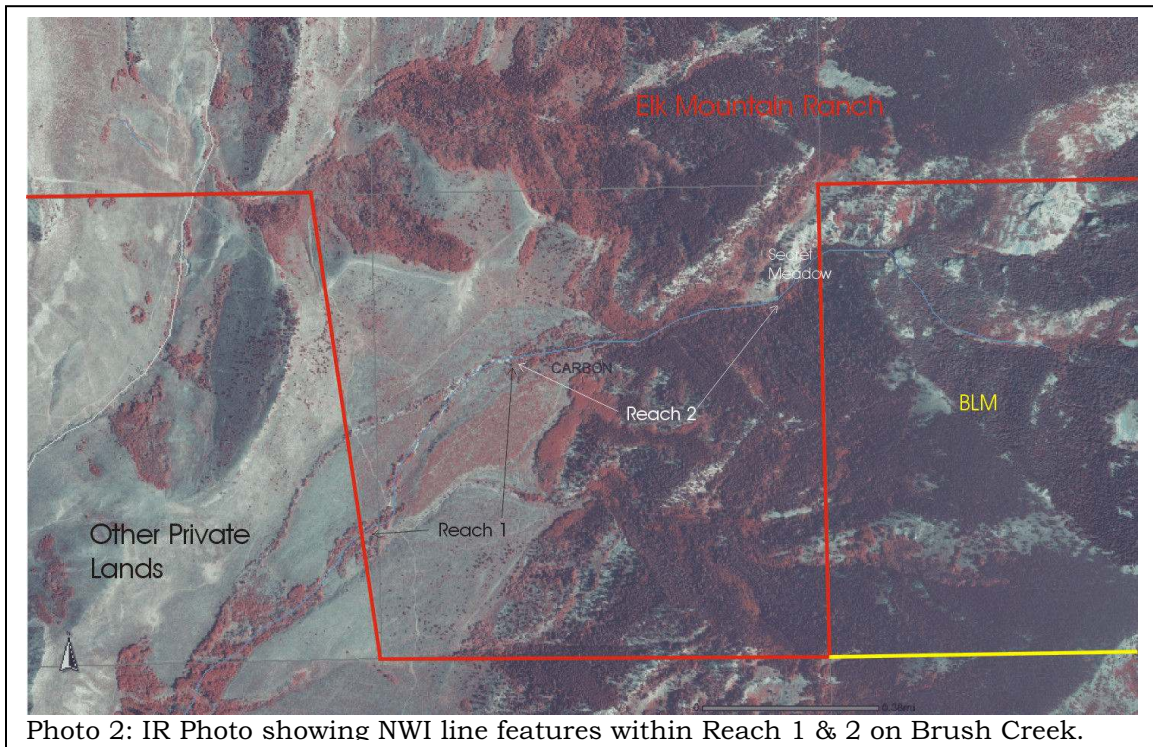


Photo 2: IR Photo showing NWI line features within Reach 1 & 2 on Brush Creek.

National Wetlands Inventory data and IR color photographs (2000) from the WyGIS Data Server (<http://partners.wygisc.uwyo.edu>) were used to identify important wetland and riparian features within Reach 1 and 2 on Rattlesnake Creek. A composite photograph showing the NWI line and polygon features, as well as PLSS and land ownership, superimposed over the color IR photo is shown above, and at a larger scale in the appendix. The IR photo, as well as ground verification in the field, would indicate that the riparian/water influence zone surrounding the stream is limited for the most part to a single narrow green-line on either side of the channel in Reach 1. Reach 2 riparian and flood plain features are more prevalent, and exhibit more robust conditions, but are still limited to a narrow green-line throughout a significant length of the reach. No NWI wetland polygon features are found within the project reach. Stream channel work will avoid impacting any critical riparian or other wetland resources along the project reach.

Stream Channel Morphology:

For the purposes of the stream channel morphology study, a representative sub-reach consisting of three existing pools and two riffles along a 160 ft segment of the creek was identified, approximately halfway between the BWSHI survey site and the upstream boundary of the reach at the Secret Meadow. Two cross-sections were established and numbered consecutively beginning at the top of the representative sub-reach and continuing downstream. The cross-sections also correspond to new pool development sites identified in the habitat enhancement plan. The channel type within the representative reach was classified as B3a (Rosgen, Catena 1994), considering slope, sinuosity, entrenchment, width/depth ratio, and substrate composition. All directional references to stream banks and cross-sectional head pins for the channel morphology study are from a hydrologist's perspective, with left and right banks determined looking downstream along the channel.

A longitudinal profile (Chart 4) of the stream channel and the two cross-sections were established in July 2007. Stream flow was measured at cross-section #1, using a Marsh-McBirney FlowMate 2000 flow meter, and was calculated to be 0.8 cfs. The longitudinal profile is typical of the steeper Ba channel type, characterized by high gradient and infrequent pool habitat. The average slope of the channel and bank full stage throughout the profile was 9.5%, and the water surface slope was 9.1%. Riffle slopes ranged from 9.5% to 14%, with brief, transitional areas exhibiting slopes of 4% to 6%. These transitional segments in the riffles are identified for conversion to pool habitat in the habitat enhancement plan. Stream channel sinuosity was low (<1.5) in the representative sub-reach, as would be expected for a Ba type channel.

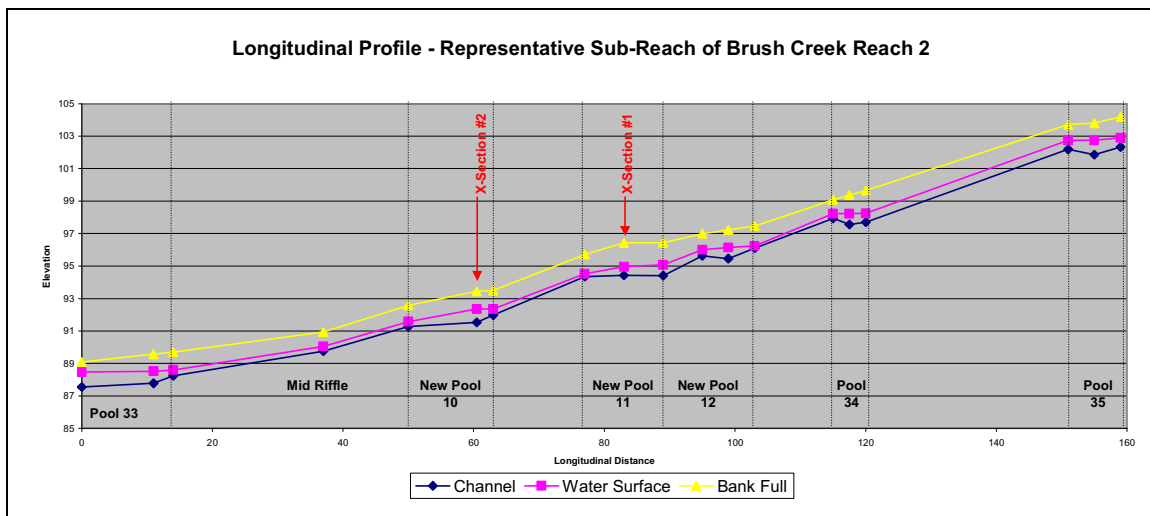


Chart 4: Longitudinal Profile of the representative segment of Reach 2 on Brush Creek.

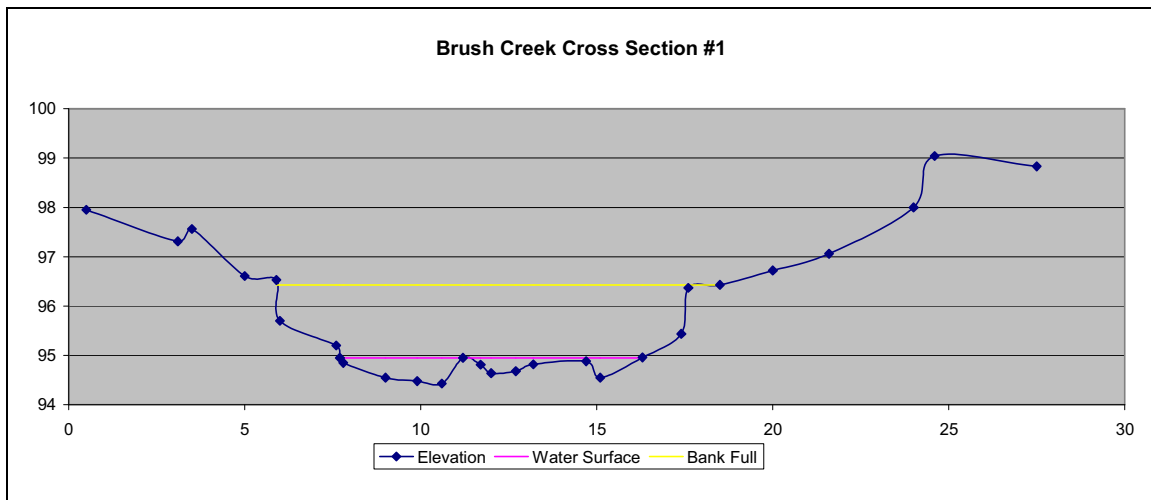


Chart 5: Cross Section #1 on Brush Creek.

Cross-sections #1 and #2 show the moderately entrenched characteristics of the stream channel within the reach. Entrenchment ratios of <1.9 were observed at each cross-section. Width/depth ratios were calculated to be <10 . Entrenchment ratios and W/D ratios were slightly higher than expected for a Ba channel type, but were likely due to the locating of the cross-sections at brief low gradient transitional areas within the representative sub-reach. The cross-sections bisect the creek at the transition between New Pool 10 and New Pool 11, described later in this document. Photographs of the cross-sections described in this section can be found in the site descriptions for New Pool 10 and New Pool 11 in the next section (page 22).

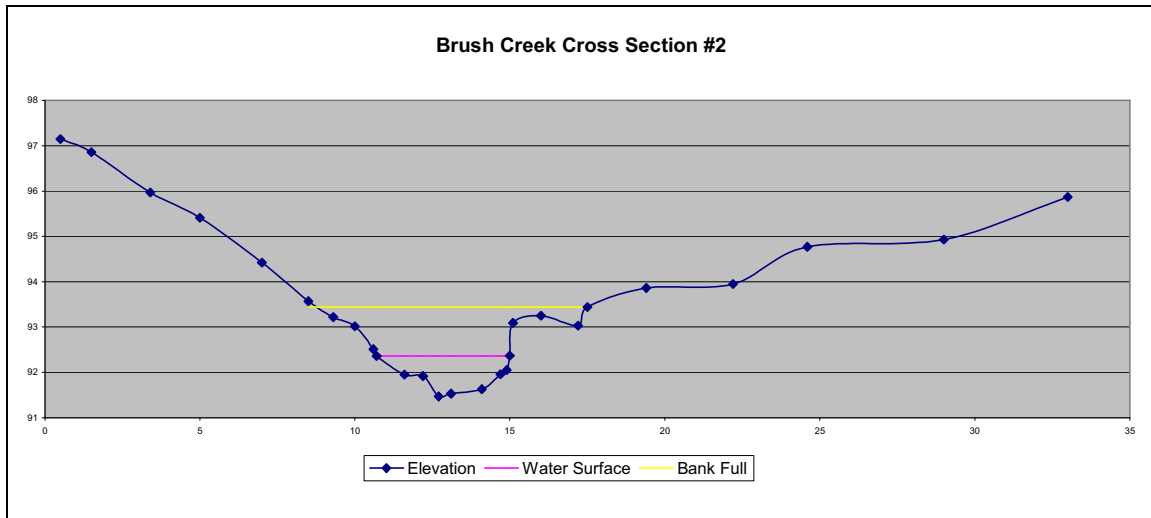


Chart 6: Cross-Section #2 on Brush Creek.

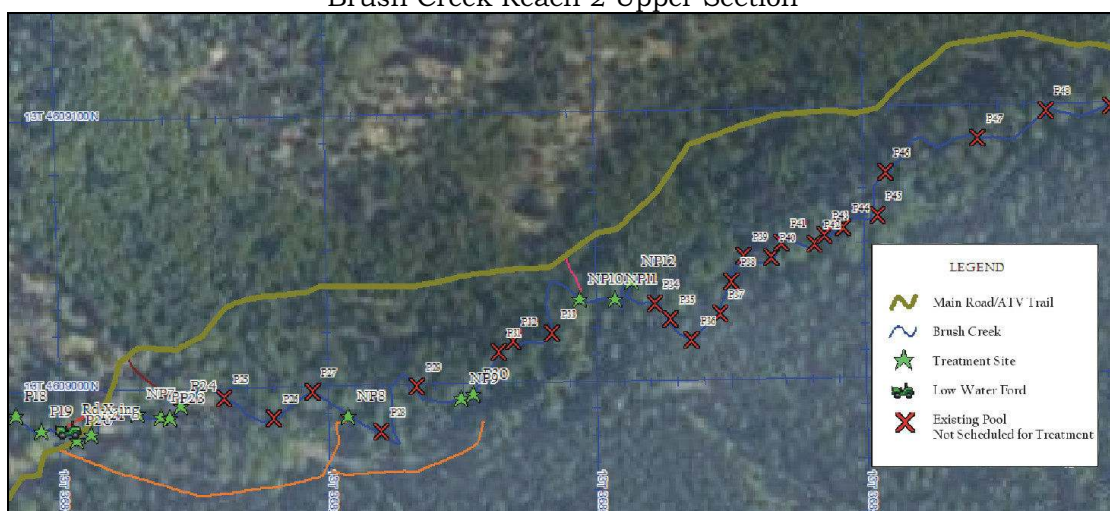
A modified Z-Walk pebble count (Bevenger, USDA 1996) was collected within the representative sub-reach to characterize the channel substrate and stream bank particle size. The results of this survey are shown in the table below. Fine particles of sand comprise only 6% of the substrate composition, with the

median particle size comprised of very coarse gravel. The D84 particle size in the reach is estimated to be comprised of large cobble measuring approximately 200mm along the medial axis. Stream substrate appears to be well armored throughout the study reach, effectively limiting pool scour and depth. Stream banks were found to be well armored throughout the sub-reach, with bank rock content composed primarily of large and small cobble.

Z-Walk		Class		Total	% of	Cumulative
Metric - mm	Inches	Name		Number	Total	%
less .066		Silt/Clay			0.0%	0.0%
.062-.125		Very Fine	SAND		0.0%	0.0%
.125-.25		Fine		6	6.0%	6.0%
.25-.50		Medium			0.0%	6.0%
.50-1.0		Coarse			0.0%	6.0%
1.0-2.0		Very Coarse		1	1.0%	7.0%
2.0-4.0		Very Fine	GRAVEL		0.0%	7.0%
4.0-8.0		Fine		2	2.0%	9.0%
8.0-16	.08-.6	Medium		4	4.0%	13.0%
16-32	.6-1.3	Coarse		14	14.0%	27.0%
32-64	1.3-2.5	Very Coarse		26	26.0%	53.0%
64-128	2.5-5.0	Small	COBBLE	21	21.0%	74.0%
128-256	5-10	Large		17	17.0%	91.0%
256-512	10-20	Small	BOULDERS	7	7.0%	98.0%
512-1024	20-40	Medium		2	2.0%	100.0%
1024-2048	40-80	Large			0.0%	100.0%
2048-4096	80-160	Very Large			0.0%	100.0%



Brush Creek Reach 2 Upper Section



Brush Creek Reach 2 Middle Section



Brush Creek Reach 2 Lower Section
Map 2: Brush Creek Reach 2 Treatment Sites.

Brush Creek Reach 2 Aquatic Habitat Enhancement Plan

The aquatic assessment indicates that poor pool development, insufficient residual pool depth, and lack of cover are significant limits to the viability of a trout fishery in the headwaters of Brush Creek. Overwintering habitats are rare, and stream bed armoring has effectively limited scour in most of the existing pools. Large cobble and small boulder substrates are effectively armoring the stream bed and preventing scour and formation of deeper pool habitats. The following chapter will describe the specific treatments recommended to address these limiting factors identified in the aquatic habitat assessment and inventory. Each treatment site will be described in detail. Technical drawings of the specific treatment types may be found in the appendix of this document.

For the purposes of the stream aquatic habitat enhancement plan, treatment sites were identified and numbered consecutively beginning at the downstream boundary of the reach and continuing upstream. All directional references to stream banks and other features are from a fisheries biologist's perspective, with left and right banks determined looking upstream along the channel.

Reach 2:

Reach 2 on Brush Creek extends from the point where the stream dries up, near the SE 1/4 of the NW 1/4 of R.82 W., T.19 N., Sec. 14., upstream to forest opening known locally as "Secret Meadow". An ATV access trail parallels the creek throughout most of the reach, terminating at the Secret Meadow, and provides good access to the creek for equipment in several locations. Access routes have been mapped, using a GPS, for the project and are shown in the Access Route Map included in the Appendix (page 33).

Most of the enhancement activity will focus on enhancing pool depth and scour within existing pool meso-habitats along the stream channel throughout the reach. This work will entail removing large cobble and small boulder from the pool habitats with a small (<10,000lb) excavator with a hydraulic thumb. Substrates removed from the stream channel will be relocated well away from the stream and surrounding riparian / water influence zones. Some of the larger boulders removed from the pools may be utilized to re-configure the pool crest in order to provide for more efficient scour through the habitat.

Additionally, several new pool habitats will be developed at suitable sites along the stream channel within the reach. Several potential barriers that were identified in the field reconnaissance will be treated to improve passage of aquatic organisms through these features. One of the treatment sites includes a low water ATV trail crossing and over-wide channel segment near the lower boundary of the reach. The locations of all these treatment areas are shown in the maps on the left. Larger versions of these location maps can also be found in the Appendix.



Photo 3 - Site P1 From the Right Bank



Photo 4 - Site NP1 Looking Upstream

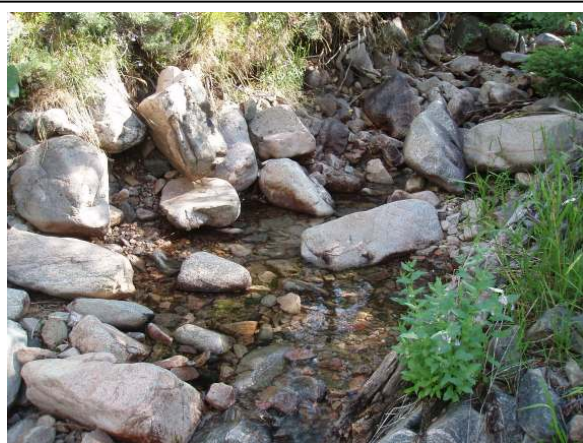


Photo 5 - Site P2 Looking Upstream.



Photo 7 - Site P3 Looking Upstream



Photo 6 - Site NP2 From the Right Bank

Treatment Site Descriptions:

Work on Pools 1 through 6, and construction of New Pools 1 and 2 will be accomplished by accessing the creek with a small excavator via the routes identified as Access 1 and Access 1a. Equipment will ingress to the stream using Access 1a, and work will be done sequentially beginning with Pool 6 and working downstream to Pool 1. The equipment will then be walked back to the ATV road on the southeast side of the stream via Access 1.

Pool #1 (P1) is located at the downstream boundary of Reach 2 (Photo 3). This pool occasionally dries up and maintains very little residual pool depth. Work on this meso-habitat will include re-aligning the existing boulders within the feature to create a boulder cross vane at the upstream transition between the pool and riffle. Additionally, large cobble and small boulder will be removed from the pool to create a residual pool depth of at least 1.0 ft and a maximum pool depth of 1.5 ft at bank full stage.

A site for New Pool #1 (NP1, Photo 4) is found approximately 75 ft upstream of Pool 1, at a brief lesser gradient transition zone within the cobble/boulder riffle. A new pool may be constructed here using existing small boulders and large cobble within the stream channel. Small boulders will also be removed from the channel to create a pool approximately ten feet long and four feet wide. Target RPD will be 1.0 - 1.2 feet, and maximum pool depth will be 1.5 ft.

Pool #2 (P2) is located 73 ft upstream of NP1 and 148 ft upstream of Pool 1 (Photo 5). This pool maintains a residual pool even when the channel is dry, but maintains very little depth. Work on this feature will include removing and re-aligning large cobble and small boulder to deepen the existing pool. The goal will be to create a residual pool depth of at least 1.0 ft and a maximum pool depth of 1.5 ft.

A site for New Pool #2 (NP2, Photo 6) is found 10 ft upstream of Pool 2, at a lesser gradient transition zone within the cobble/boulder riffle. A new pool may be constructed here using existing small boulders and large cobble within the stream channel. Small boulders will also be removed from the channel to create a pool approximately ten feet long and four feet wide. Target RPD will be 1.0 - 1.2 feet, and maximum pool depth will be 1.5 ft.

The existing pool at P3 is found 75 ft upstream of Pool 2, and will be enlarged and defined by removing armor from the stream channel (Photo 7). Larger cobble and boulder will be used to create a cross vane at the upstream boundary of the habitat to enhance scour through the feature. Target RPD will be 1.0 - 1.2 feet, and maximum pool depth will be 1.5 ft.

Pool 4 (P4) is 60 ft upstream of Pool 3, and features a naturally occurring cross-vane composed of small boulder (Photo 8). The boulders will be adjusted to improve scour, and some armor will be removed from the pool to improve RPD and depth. Target RPD will be 1.0 - 1.2 feet, and maximum pool depth will be 1.5 ft.

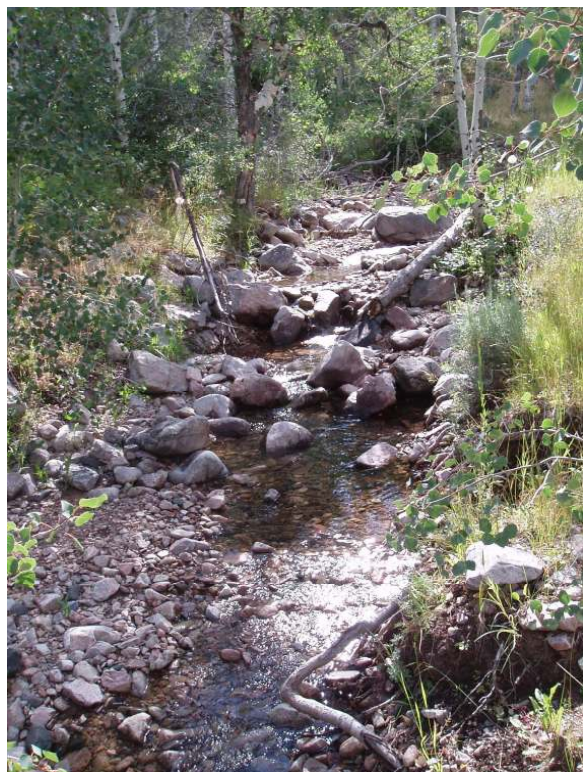


Photo 8 - Site P4 Looking Upstream



Photo 9 - Site P5 From the Right Bank



Photo 10 - Site P6 Looking Upstream



Photo 12 - P11 Looking Upstream



Photo 11 - P8 & P9 Looking Downstream

Pool 5 (P5) is similar to Pool 4, and is located 55 ft upstream (Photo 9). This pool also features a naturally occurring cross-vane composed of two large boulders. These boulders will be adjusted to improve scour, and some armor will be removed from the pool to improve RPD and depth. Target RPD will be 1.0 - 1.2 feet, and maximum pool depth will be 1.5 ft.

Pool 6 (P6) is similar to the preceding pools, and is located 80 ft upstream of P5 (Photo 10). This pool also features a naturally occurring cross-vane composed of several small boulders. These boulders will be adjusted to improve scour, and some armor will be removed from the pool to improve RPD and depth. Target RPD will be 1.0 - 1.2 feet, and maximum pool depth will be 1.5 ft.

Pool 7, 68 ft upstream of Pool 6, does not have a good access route, and will therefore not be included in this program of work. Pools 8 through 12 are approximately 200 ft upstream of Pool 6, and will be approached using the Access 2 approach route on the northwest side of the stream. Upon completion of the work on these features, the equipment will be moved to Pool 13 & 14 using the Access 2A route.

Pools 8, 9 and 10 are a closely spaced step-pool feature within a relatively steep channel segment (Photo 11). There is a potential barrier to fish passage at Pool 8, due to the very shallow depth of the pool and a considerable (1.5 ft) hydraulic jump at the upstream boundary of the habitat. This potential barrier will be minimized by deepening the pool to allow trout to obtain the necessary burst speed to pass this feature at low flow. The pool will be deepened to a maximum depth of 2 feet below the bank full stage by removing cobble from the bed.

Pool 9 will be enlarged to encompass the entire channel width by re-aligning and removing larger substrate material within the channel. Pool 10 will also be deepened by removing armor from the bed. Target average depths in these pools will be 1.2 to 1.4 ft, with RPD of at least 1.25 ft. Maximum depth of these pools will be 1.5 to 2 ft, depending on the composition of the stream substrate.

Pool 11 is located 80 ft upstream of the P8/9/10 step-pool complex, where the stream channel exhibits a somewhat lesser gradient, and returns to more of a Ba-Channel type of pool/riffle sequence (Photo 12). Pool 11 is another poorly developed pool, comprising less than 1/2 of the channel width, with limited scour due to channel armoring. We will use existing boulders in the feature to construct a small rock vane to enhance scour, and remove enough cobble armor in the bottom of the pool to make this a full-channel width habitat. Targeted RPD will be 1.2 - 1.4 ft, with a maximum depth of 1.5 -2.0 ft.

Pool 12 (Photo 13) is located 42 ft upstream of Pool 11, and is formed by a piece of large wood embedded into the channel. Pool 11 exhibits limited scour due to channel armoring. Existing boulders in the feature will be used to improve scour over the existing log, which will not be disturbed. Cobble armor in the bottom of the pool will be removed from the habitat to reach a targeted RPD of 1.0 ft and a maximum depth of 1.5 ft.



Photo 13 - P12 Looking Downstream



Photo 14 - P14 Looking Upstream



Photo 15 - P16 Looking Upstream



Photo 16 - NP3 Looking Upstream



Photo 17 - NP4, 5 & 6 - From Left Bank

Pool 13 is located 62 ft upstream of Pool 12, and is reached via the Access 2A approach route. The pool is formed by a piece of large wood embedded into the channel. Pool 12 exhibits limited scour due to channel armoring. Existing boulders in the feature will be used to improve scour over the existing log, which will not be disturbed. Cobble armor in the bottom of the pool will be removed from the habitat to reach a targeted RPD of 1.0 ft and a maximum depth of 1.5 ft.

Pool 14 may also be accessed via the Access 2A route, and is approximately 87 ft upstream of Pool 13 (Photo 14). The stream channel gradient at this point begins to increase, exhibiting characteristics of an A channel step-pool system. There is a potential barrier to fish passage at this pool, due to the very shallow depth of the pool and a large (>1.0 ft) hydraulic jump at the upstream boundary of the habitat. Boulders and large wood along this segment will be re-aligned to create a series of three step pools to eliminate the potential barrier. Each step pool feature will be deep enough to allow trout to obtain the necessary burst speed to pass this feature at low flow. The step pool pockets will be deepened to a maximum depth of 1.5 feet below the bank full stage.

Pool 15 is located 62 ft upstream of Pool 14, and may be accessed from the Access 3A route on the northwestern side of the stream. Pool 15 suffers from the same lack of scour and depth as the other pools described in this chapter, and will be enhanced by removing armor from the stream bed and re-aligning the boulders at the head of the habitat. RPD will be increased to greater than 1.0 ft, and maximum depth will be increased to 1.5 ft at the bank full stage.

Pool 16 (Photo 15) is 32 ft upstream of Pool 15, and exhibits the first quality pool habitat encountered along Reach 2. This habitat feature will be left "as is", with no additional enhancement necessary. Pool 16 is formed by a boulder constriction creating a natural plunge into the center of the channel. Maximum depth is 1.5 ft, with an RPD of 1.1 ft.

The site for New Pool 3 (NP3, Photo 16) is found 60 ft upstream of Pool 16, in a brief, high gradient segment of the stream channel, and may be accessed either by Access3A or Access3. There is another potential barrier to fish passage at NP3, due to a series of hydraulic jumps through a boulder cascade with no pockets of deep water resting cover. This potential barrier will be minimized by creating a new plunge pool at this location to allow trout to obtain the necessary burst speed to pass the hydraulic jump at low flow. Armor will be removed to create a pool with a maximum depth of 2 feet below the bank full stage and a RPD of 1.2 to 1.4 ft.

New Pool Sites 4 -6, and Pool 17 & 18 may be reached by following the Access 3 route to the downstream boundary of the BWSHI habitat study reach described in the preceding section. New Pool 4 and 6 (NP4 & 6, Photo 17) correspond with pools 1 & 2 in the BWSHI study. Neither of these pools currently exhibit cover for salmonids. New Pool site 5 (NP5) is found 52 ft upstream of NP4 within riffle2 in the BWSHI survey, at brief gradient transition within the habitat feature. Current RPD for these features is 0.5 ft and current maximum depth is



Photo 18 - P17 Looking Upstream



Photo 19 - P18 From the Right Bank



Photo 20 - P20 Looking Upstream



Photo 21 - P21 From the Right Bank



Photo 22 - Rd X-ing Upstream of P21

0.75 ft. RPD and maximum depth will be doubled in these habitats by removing substrate armoring in channel.

Pool Site 17 (P17, Photo 18) corresponds with pool 3 in the BWSHI survey, and is located 16 ft upstream of NP6. This pool currently has no measured cover for trout, with RPD of 0.6 ft and a maximum depth of 0.8 ft. Armor will be removed from the channel within this habitat feature to create a full channel pool with an RPD of at least 1.0 ft and a maximum depth of 1.5 ft.

Pool Site 18 (P18, Photo 19) is a pocket water feature within riffle 3 in the BWSHI survey, and is located 50 ft upstream of P17. This pocket water feature occupies less than 1/2 the width of the channel, and is formed by a large log in the channel. This feature will be enhanced by re-aligning the log as a vane on the right bank of the stream to improve scour along the entire width of the channel. Armor will be removed from this habitat feature to create a full channel pool with an RPD of at least 1.0 ft and a maximum depth of 1.5 ft.

Pools 19 & 20 (P19, P20), are located a short distance downstream of the road crossing, and may be reached using the Access 4 route along the northwest side of the creek. P19 corresponds to the first glide habitat in the BWSHI survey, and will be converted to a pool through deepening by removing cobble and boulder. Pool 20 is a pocket water feature within riffle 4 in the BWSHI survey, and is located 10 ft upstream of P19 (Photo 20). This pocket water feature occupies less than 1/2 the width of the channel, and is formed by several large boulders in the channel. Additionally, twenty feet of actively eroding stream bank is present along the right bank of this feature. The boulders will be re-aligned to improve scour along the entire width of the channel. Armor will be removed from this habitat feature to create a full channel pool with an RPD of at least 1.0 ft and a maximum depth of 1.5 ft. The eroding stream bank will be treated and revegetated using a single log toe-slope stabilization structure. The log toe slope structure should not exceed greater than 0.1 yd³ of fill per linear foot of bank treated, and will not constrict the bank full cross-sectional area of the stream channel through this habitat.

Pool 21 is immediately downstream of the ATV trail crossing, and corresponds to pool 5 in the BWSHI survey. The pool is formed by a debris jam of large wood and boulder (Photo 21), and appears to be one of the most significant barriers to fish passage within the reach, due to very limited pool depth and a hydraulic jump of greater than 1.5 ft. The large wood forming this habitat feature will be removed and replaced by a boulder cross-vane structure to stabilize the vertical profile of the stream channel at the road crossing. This potential barrier will be minimized by deepening and enlarging the plunge pool at this location to allow trout to obtain the necessary burst speed to pass the hydraulic jump at low flow. Armor will be removed to create a pool with a maximum depth of 2 feet below the bank full stage and a RPD of 1.2 to 1.4 ft.

The trail crossing (Rd X-ing) corresponds to riffle 6 in the BWSHI survey, and is characterized by an over wide channel with multiple braiding and shallow depth (Photo 22). The stream throughout this feature will be narrowed to a single thread using large wood to define the stream banks, and the approach to the



Photo 23 - NP7 Looking Upstream

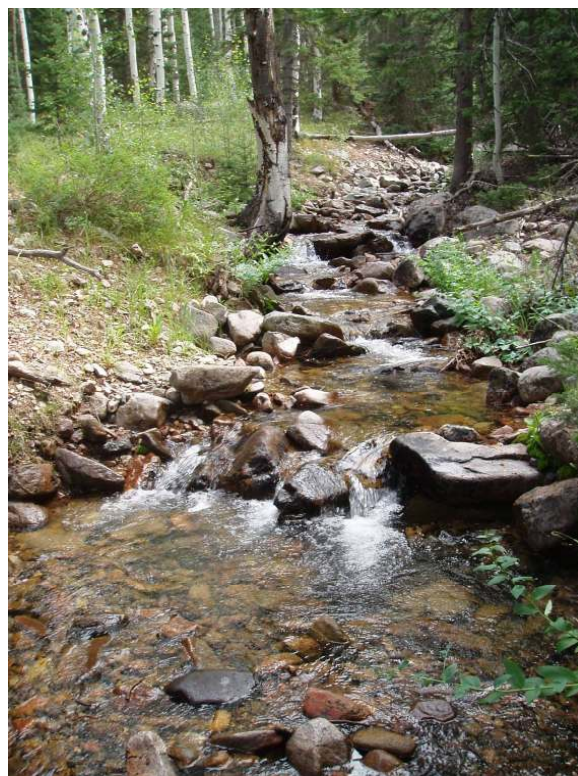


Photo 24 - P22, P 23, & P24 Step-Pools

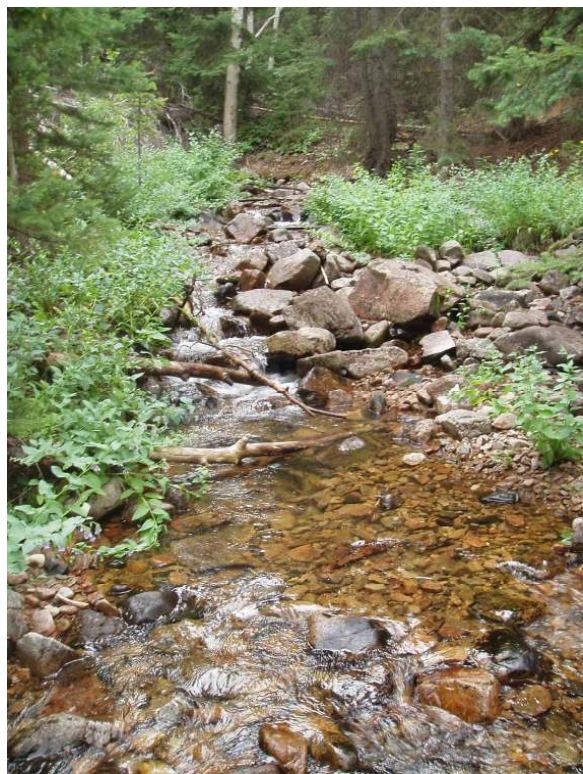


Photo 25 - NP8 Looking Upstream

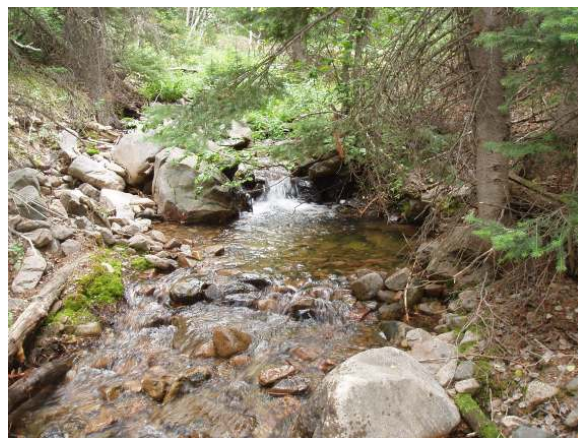


Photo 26 - Plunge Pool

crossing will be hardened using cobble available from sources nearby the stream. The current channel width of >12 ft will be narrowed to 8 ft, slightly wider than the natural average width of undisturbed riffles in the reach. four pieces of large wood will need to be harvested from the forest nearby to do this work.

New Pool Site 7 (NP7, Photo 23) is located within the riffle 7 habitat unit described in the BWSHI survey, where a large woody debris jam has caused the stream to abandon the original channel and cut a new channel through the riparian vegetation on the left bank. Work at this site will include removing the debris jam and re-establishing the stream in the old channel. Large wood within the debris jam will be used to construct a double log cross-vane structure and new pool at this point along the stream channel.

Pools 22, 23 and 24 are a closely spaced step-pool feature within a relatively steep channel segment (Photo 24), and correspond to pool 8 and pocket water features in riffle 9 in the BWSHI survey. This segment may be accessed using the Access 5 route on the northwest side of the stream. The existing pool and the pocket water features will be deepened to approximately 1.5 ft by removing large cobble from the bed of the stream in these features.

Pools at sites P25, P26 and P27 are not accessible by equipment, and will not be treated under this project. The new pool site at NP8 (Photo 25) may be approached from the southeast side of the creek following the Access 6 route. A boulder plunge pool will be created here using large boulders from the riffle immediately upstream to create a cross-vane. Cobble armoring the channel within the habitat will be removed to achieve an RPD of >1.0 ft and a maximum depth of 1.5 - 2.0 ft.

Pool site P28 is another shallow pool limited by cobble armor within the stream channel. The hydraulic jump upstream of this feature may also create a barrier during some flows. The pool will be deepened to allow trout to obtain the necessary burst speed to pass the hydraulic jump at low flow. Armor will be removed to create a pool with a maximum depth of 2 feet below the bank full stage and a RPD of 1.2 to 1.4 ft.

The existing pool at site P29 (Photo 26) corresponds to pool 10 in the BWSHI survey, and exhibits some of the best pool habitat and cover of any pool in Reach 2. Nearly 1/4 of the wetted perimeter of this feature contains some form of cover for trout, with a maximum depth exceeding 1.8 ft and a RPD of 1.3 ft. This habitat will not be altered under this project, and will, in fact, be used as a reference to compare enhancements in the reach.

The next two sites, New Pool 9 and Pool 30, may be accessed from the southeast side of the creek following an old skid trail shown as Access 6A on the Access Route Map. These sites correspond with riffle 14 and pool 14 in the BWSHI survey, near the upstream boundary of the BWSHI representative sub-reach.



Photo 27 - NP9 Looking Upstream



Photo 28 - P30 Looking Upstream



Photo 29 - NP10 Looking Downstream
Longitudinal Profile Site - X-Sec. #2



Photo 30 - NP11 & 12. Longitudinal Profile
Site - X-Sec. #1

New Pool site 9 (NP9) will convert a small pocket within a higher gradient pocket water riffle to a full channel boulder plunge pool by reconfiguring boulder within the channel to create a cross vane feature. Additionally, the forty feet of unstable right stream bank will be treated with large wood to stabilize the toe slope of the bank. The log toe slope structure will require two large trees, harvested from an adjacent area along the access route that is outside the water influence zone, and should not exceed greater than 0.1 yd³ of fill per linear foot of bank treated. The bank stabilization work will not constrict the bank full cross-sectional area of the stream channel through this habitat.

Pool 30 is a very shallow plunge pool feature formed by boulder (P30, Photo 28). This pool currently provides only a small amount of overhead cover for trout, with RPD of 0.8 ft and a maximum depth of 1.0 ft. Armor will be removed from the channel within this habitat feature to create a full channel pool with an RPD of at least 1.0 ft and a maximum depth of 1.5 ft.

Pool sites 31 and 32 (P31 & P32) correspond with pools 15 and 16 in the BWSHI survey. Pool site 33 (P33) is outside of the BWSHI sub-reach, and is located approximately 100 ft downstream of the Longitudinal Profile/Stream Morphology sub-reach identified in the previous section. The stream exhibits a notably steeper gradient throughout this segment, more like an A type channel, and flows through a very dense mixed conifer forest. Although these pools are limited by the same channel substrate armoring, lack of depth and cover found in other segments of the reach, there is no practical way to access these habitats with equipment, so they have been dropped from the project. It may be possible to treat these features by hand; manually removing small cobble to enhance scour within the existing pools.

New Pool sites NP10, NP11, and NP12 are located between Pools 33 and 34, and are within the Longitudinal Profile/Stream Morphology sub-reach described in the previous section (Photos 29 & 30). These three sites may be accessed from the road to Secret Meadow on the northwest side of the creek using the Access 12 route. Three new plunge pools will be constructed using existing boulders in the channel and along the banks to place cross-vanes in the channel at brief, low-gradient transition zones along the steeper cobble/boulder dominated riffle. Armor will be removed from the pooling and scour zone downstream of each cross vane to create a full channel width pool. Targeted residual pool depth will be 1.0 - 1.2 ft in each pool and maximum pool depth will be 1.5 - 2.0 ft.

The next 1,200 ft of stream exhibits the steeper gradient and characteristics of an A type channel. The stream flows through a very dense forest, and is a few hundred feet from the road. Twenty-one pools (P34 - P55) were identified within this segment, and for the most part, these features tend to be clustered together in groups exhibiting a step-pool morphology. As the stream enters Secret Meadow, the channel returns to a B3a form, and the pools tend to be spaced at 11 - 16 channel widths along the longitudinal axis of the stream. Some of these pools are limited by the same channel substrate armoring, lack of depth and cover found in other segments of the reach, however, there is no practical way to access these habitats with equipment, so they have been dropped from the



Photo 32 - NP13 From the Left Bank



Photo 31 - P56 Looking Downstream



Photo 33 - NP14 Looking Upstream.



Photo 34 - P58 Looking Downstream



Photo 35 - NP15 Looking Upstream

project. It may be possible to treat some of these features by hand; manually removing small cobble to enhance scour within these habitats.

The remaining new pool and pool enhancement sites are adjacent to Secret Meadow, near the upstream boundary of Brush Creek Reach 2, and may be approached via four access routes identified in the field reconnaissance. The first pool that can be accessed from Secret Meadow is Pool 56 (Photo 31) along the route identified as Access 10. Pool 56 is a very shallow plunge pool feature formed by boulder. Stream bed cobble will be removed from the channel within this habitat feature to create a full channel pool with an RPD of at least 1.0 ft and a maximum depth of 1.5 ft.

New Pool site 13 (NP13, Photo 32) may also be accessed via the Access 10 route, and is found 36 ft upstream of Pool 56. The site at NP13 is a natural low-gradient transition along a steep cobble/boulder pocket water dominated riffle. There is a significant hydraulic jump upstream of this feature that may create a barrier to fish passage during low flows. A new cross-vane plunge pool will be constructed at this site, using existing boulders and large wood, to provide additional pool habitat and to allow trout to obtain the necessary burst speed to pass the hydraulic jump at low flow. Armor will be removed to create a pool with a maximum depth of 2 feet below the bank full stage and a RPD of 1.2 to 1.4 ft.

Pool 57 is another shallow plunge pool, very similar in form to Pool 56 and located 100 ft upstream. P57 may be approached from the Secret Meadow using the Access 9 route. Stream bed cobble will be removed from the channel within this habitat feature to create a full channel pool with an RPD of at least 1.0 ft and a maximum depth of 1.5 ft.

New Pool site 14 (NP14, Photo 33) may also be accessed via the Access 9 route, and is found 50 ft upstream of Pool 57. The site at NP14 is a natural low-gradient transition ideally suited for a double log cross-vane structure and new plunge pool. The cross-vane plunge pool will be constructed using existing boulders and large wood adjacent to the site, to provide additional pool habitat. Armor will be removed downstream of the cross-vane to create a pool with a maximum depth of 2 feet below the bank full stage and a RPD of 1.2 to 1.4 ft.

Pool 58 is a shallow debris dam pool located 124 ft upstream of Pool 57 (Photo 35). P58 may be approached from the Secret Meadow using the Access 8 route. Pool 58 is another feature ideally suited for a double log cross vane to increase depth of the dam pool, as well as creating a new plunge pool immediately downstream of the structure. The cross-vane will be constructed using existing boulders and large wood adjacent to the site.

New Pool site 15 (NP15, Photo 35) may also be accessed via the Access 8 route, and is found 34 ft upstream of Pool 58. A small plunge pool will be constructed at NP15 using existing boulders in the channel. Armor will be removed downstream of the cross-vane to create a pool with a maximum depth of 1.5 feet below the bank full stage and a RPD of >1.0 ft.



Photo 36 - P59 & P60 Looking Upstream



Photo 37 - P62 Looking Downstream.



Photo 38 - P65 Looking Downstream

Pools 59 and 60 (P59 & P60, Photo 36) are shallow plunge pools located 110 ft upstream of Pool 58. These pools can be approached from the Secret Meadow using the Access 8 route. Stream bed cobble will be removed from the channel within these two habitat features to create pools with an RPD of at least 1.0 ft and a maximum depth of 1.5 ft.

The next 340 ft of stream is a few hundred feet from the southern edge of the Secret Meadow, and is not accessible by equipment. Four existing pools (P61 - P64) were identified within this segment. One of these pools, Pool 62 (P62, Photo 37) is formed by a small woody debris dam, and may be enhanced without the use of heavy equipment by adding additional wood to the dam. Two small trees will be cross-felled into the stream channel immediately downstream of the debris dam to gradually capture an accumulation of leaves and smaller woody materials, leading to improved depth of the existing dam pool.

Pool 65 is another shallow debris dam pool (Photo 38). P65 may be approached from the Secret Meadow using the Access 7 route near the upstream boundary of Reach 2. Pool 65 is formed by a large woody debris dam, and may be enhanced using the same technique of small tree cross-felling described above for Pool 62. In addition to adding woody debris to the dam, cobble armor will

be removed from the existing pool substrate to increase with a maximum depth of 1.5 feet below the bank full stage and a RPD of >1.0 ft.

New Pool site 16 (NP16) may also be accessed via the Access 7 route, and is found 30 ft upstream of Pool 65. A plunge pool will be constructed at NP16 using existing boulders in the channel. Armor will be removed downstream of the cross-vane to create a pool with a maximum depth of 1.5 feet below the bank full stage and a RPD of >1.0 ft.

Four more existing pools were identified upstream of this point. However, the stream channel becomes increasingly steep with large accumulations of downed large wood within and adjacent to the channel, making access difficult or impossible. Due to the difficulty of access to these habitats, they have been dropped from the project.

Summary:

The table below lists the sites along Brush Creek Reach 2 that will be treated under this project. The table includes each site name as shown on the GPS location map, the treatment type, and an estimate of cut (armor removal) and fill (installation of new structures). The project is predominately concerned with increasing pool volume, depth and cover, as well as increasing over-wintering capacity for salmonids throughout the reach.

REACH 2		Estimated	
Site	Treatment Type	Cut (Yd ³)	Fill (Yd ³)
Existing Pool Enhancement			
P1	Re-Align Existing Boulders - Remove Cobble Armor	0.2	<0.1
P2	Re-Align Existing Boulders - Remove Cobble Armor	0.2	<0.1
P3	Cross-Vane - Remove Cobble Armor	0.2	3
P4	Re-Align Existing Boulders - Remove Cobble Armor	0.2	<0.1
P5	Re-Align Existing Boulders - Remove Cobble Armor	0.2	<0.1
P6	Re-Align Existing Boulders - Remove Cobble Armor	0.2	<0.1
P9	Re-Align Existing Boulders - Remove Cobble Armor	0.2	<0.1
P10	Remove Cobble Armor	0.2	N/A
P11	Rock Vane - Remove Cobble Armor	0.2	2
P12	Re-Align Existing Boulders - Remove Cobble Armor	0.2	<0.1
P13	Re-Align Existing Boulders - Remove Cobble Armor	0.2	<0.1
P15	Re-Align Existing Boulders - Remove Cobble Armor	0.2	<0.1
P17	Remove Cobble Armor	0.2	N/A
P18	Re-Align Large Wood into Vane - Remove Cobble	0.2	1
P19	Convert Glide to Pool Habitat - Remove Cobble	0.25	N/A
P20	Remove Cobble Armor - Log Toe Slope Str.	0.2	2
P22	Remove Cobble Armor	0.2	<0.1
P23	Remove Cobble Armor	0.2	<0.1
P24	Remove Cobble Armor	0.2	<0.1
P30	Remove Cobble Armor	0.2	<0.1
P56	Remove Cobble Armor	0.2	<0.1
P57	Remove Cobble Armor	0.2	<0.1
P58	Double Log Cross-Vane - Remove Cobble Armor	0.2	3

REACH 2		Estimated	
Site	Treatment Type	Cut (Yd³)	Fill (Yd³)
Existing Pool Enhancement (Cont.)			
P59	Remove Cobble Armor	0.2	<0.1
P60	Remove Cobble Armor	0.2	<0.1
P62	Tree-Top Cross-Felling to Create Debris Dam	0.2	2
P65	Tree-Top Cross-Felling to Create Debris Dam	0.2	2
Barrier Removal / Mitigation			
P8	Deepen Pool - Remove Cobble Armor	0.25	N/A
P14	Re-Align Boulders to Create Step Pools	0.2	2
NP3	Cross-Vane - Create New Plunge Pool	0.25	3
P21	Cross-Vane - Deepen Existing Plunge Pool	0.25	5
Rd X-ing	Narrow Over-wide Channel Using Large Wood	N/A	6
P28	Deepen Pool - Remove Cobble Armor	0.25	N/A
NP13	Cross-Vane - Create New Plunge Pool	0.25	3
New Pool Sites			
NP1	Cross-Vane - Remove Cobble Armor	0.2	3
NP2	Cross-Vane - Remove Cobble Armor	0.25	3
NP4	Re-Align Existing Boulders - Remove Cobble Armor	0.2	<0.1
NP5	Re-Align Existing Boulders - Remove Cobble Armor	0.2	<0.1
NP6	Re-Align Existing Boulders - Remove Cobble Armor	0.2	<0.1
NP7	Double Log Cross-Vane - Remove Cobble Armor	0.25	3
NP8	Cross-Vane - Remove Cobble Armor	0.25	3
NP9	Cross-Vane - Remove Cobble Armor	0.25	3
NP10	Cross-Vane - Remove Cobble Armor	0.25	3
NP11	Cross-Vane - Remove Cobble Armor	0.25	3
NP12	Cross-Vane - Remove Cobble Armor	0.25	3
NP14	Double Log Cross-Vane - Remove Cobble Armor	0.3	3
NP15	Cross-Vane - Remove Cobble Armor	0.25	3
NP16	Cross-Vane - Remove Cobble Armor	0.25	3
Total Project Estimated Cut and Fill		<11 Yd³	<69 Yd³

Thirty-one of the seventy existing pool habitats in the reach will be enhanced to provide additional over wintering habitat, depth and cover. It is estimated that the work will increase in-channel, combination and pool cover in the reach by approximately 500 square feet, increasing overall cover for trout in the reach more than 300%. Seven potential barriers to fish passage will be treated within the reach, allowing movement of salmonids and other important aquatic organisms throughout the project area. Sixteen new pools will be constructed, further increasing total pool area by 23% in the reach. Upon completion of the project, pool habitats are expected to comprise approximately 3% more of the total wetted perimeter of Reach 2; up to 17% of the reach

APPENDIX

Location Maps

NWI/Color IR Photo of Project Site

Stream Channel Structure and Treatment Drawings

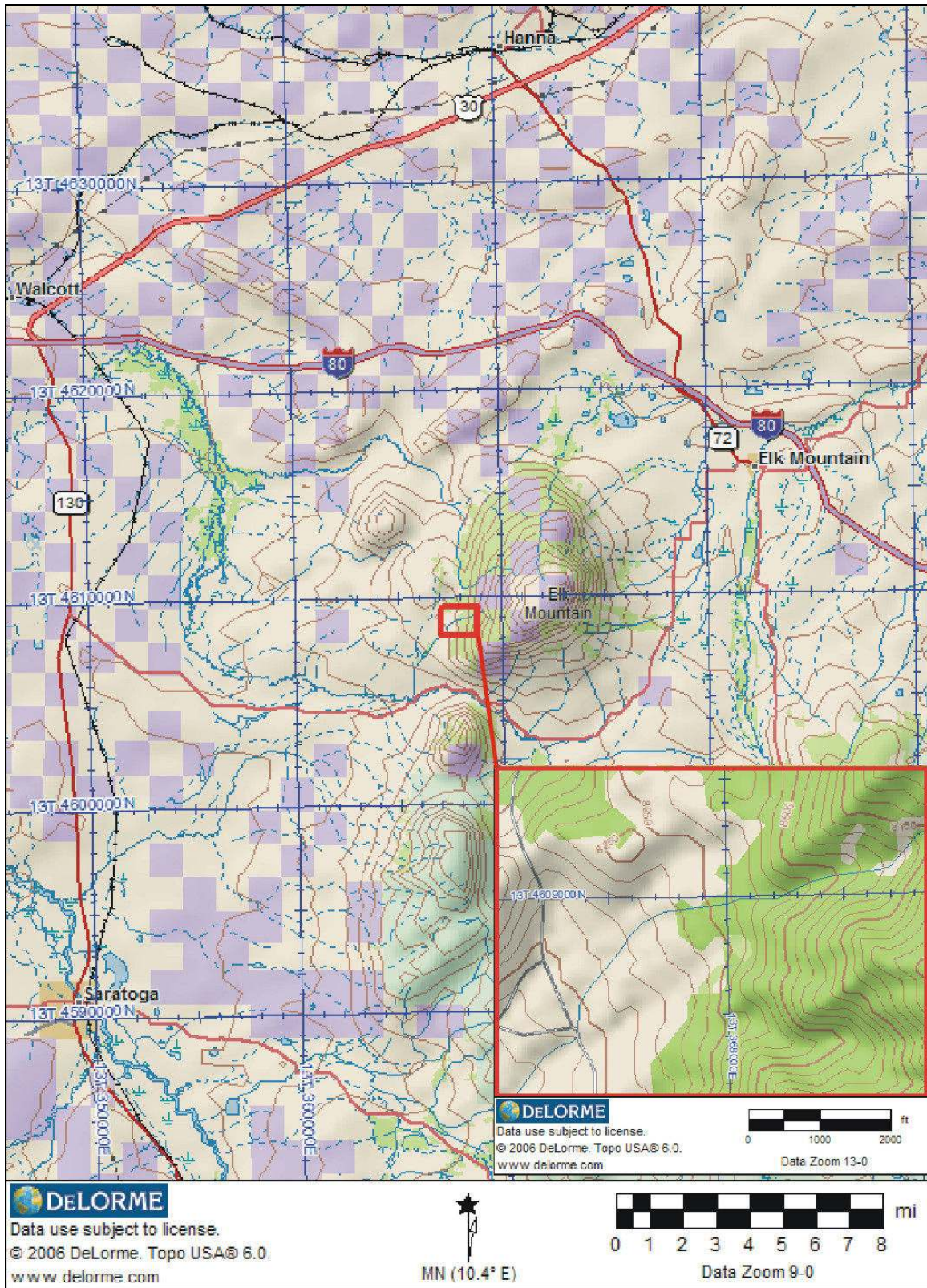
Photographic Representations of Treatment Types

Longitudinal Profile & Cross Section Plots

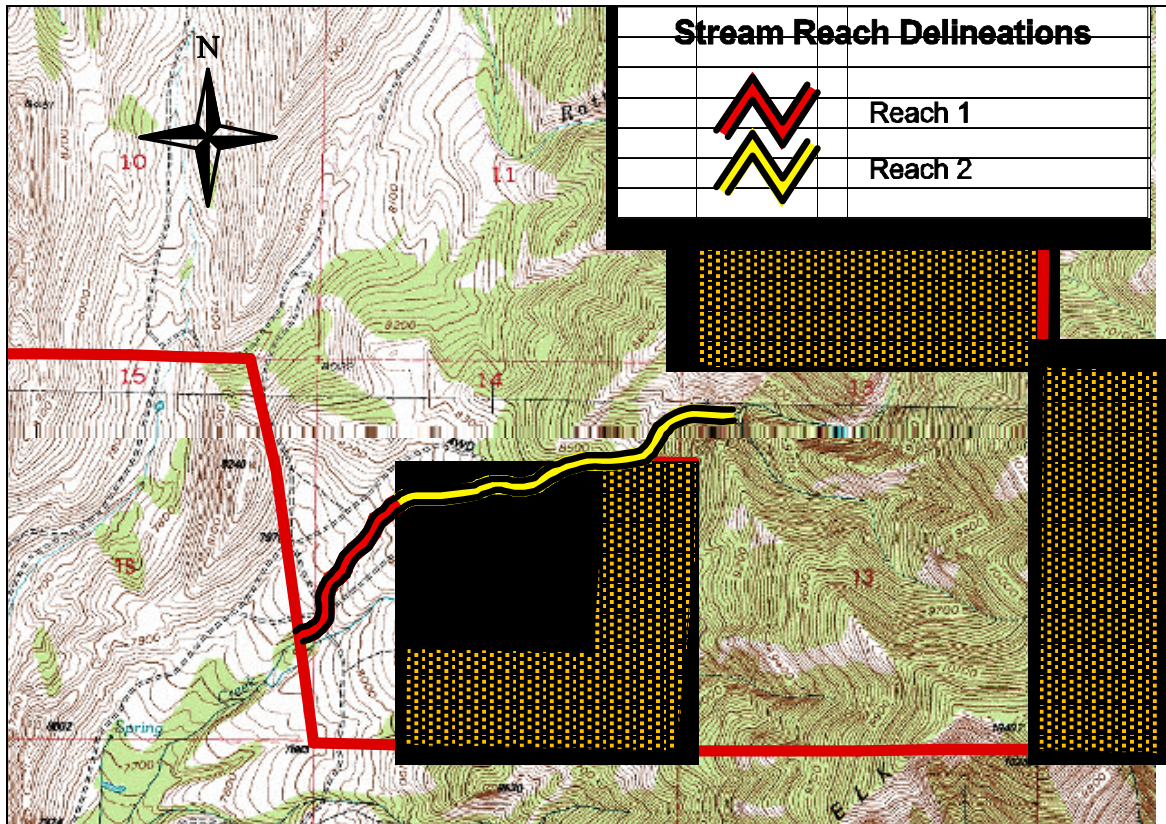
Basin-wide Stream Survey (BWSHI) Data

References

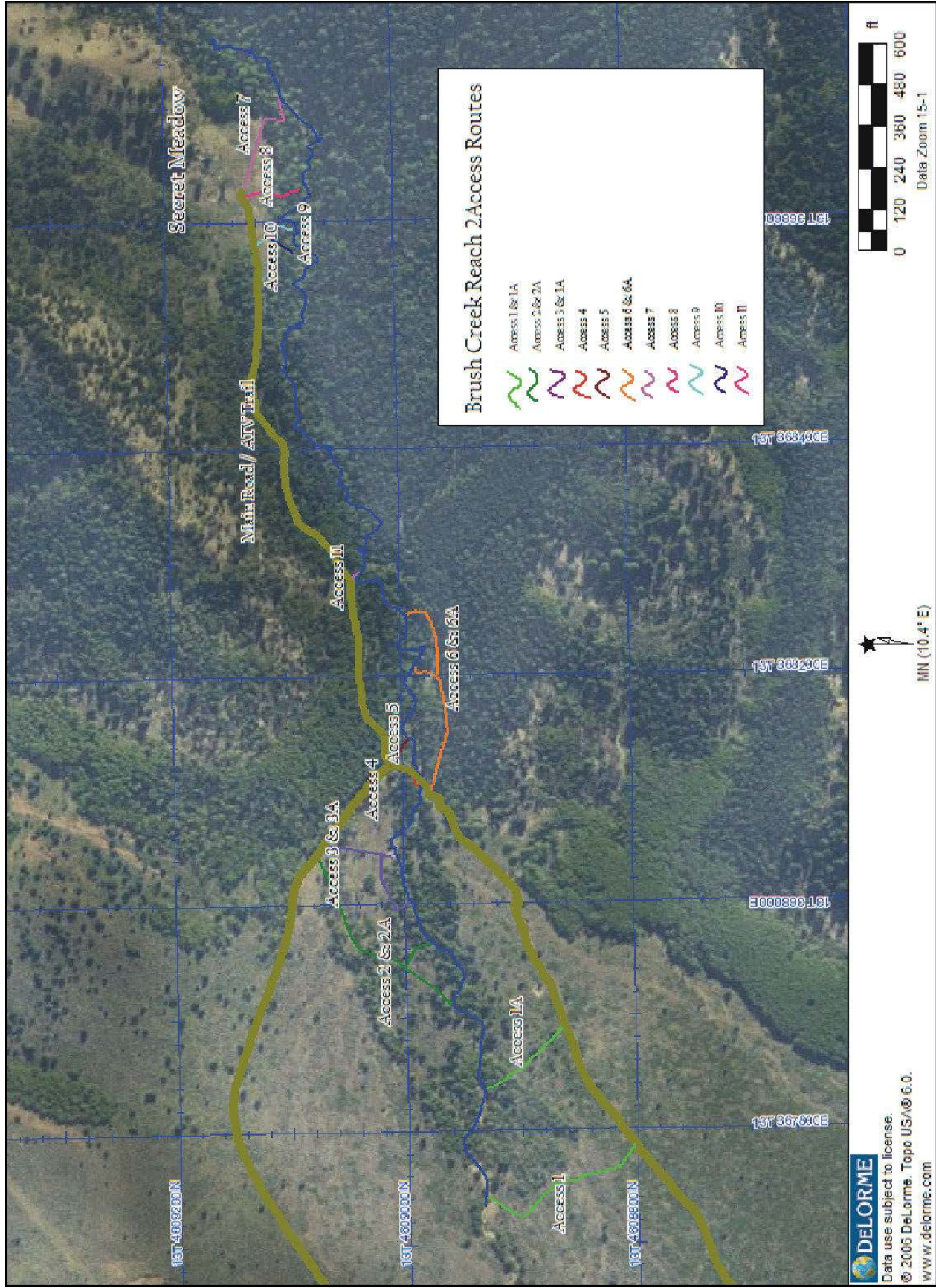
Location Maps



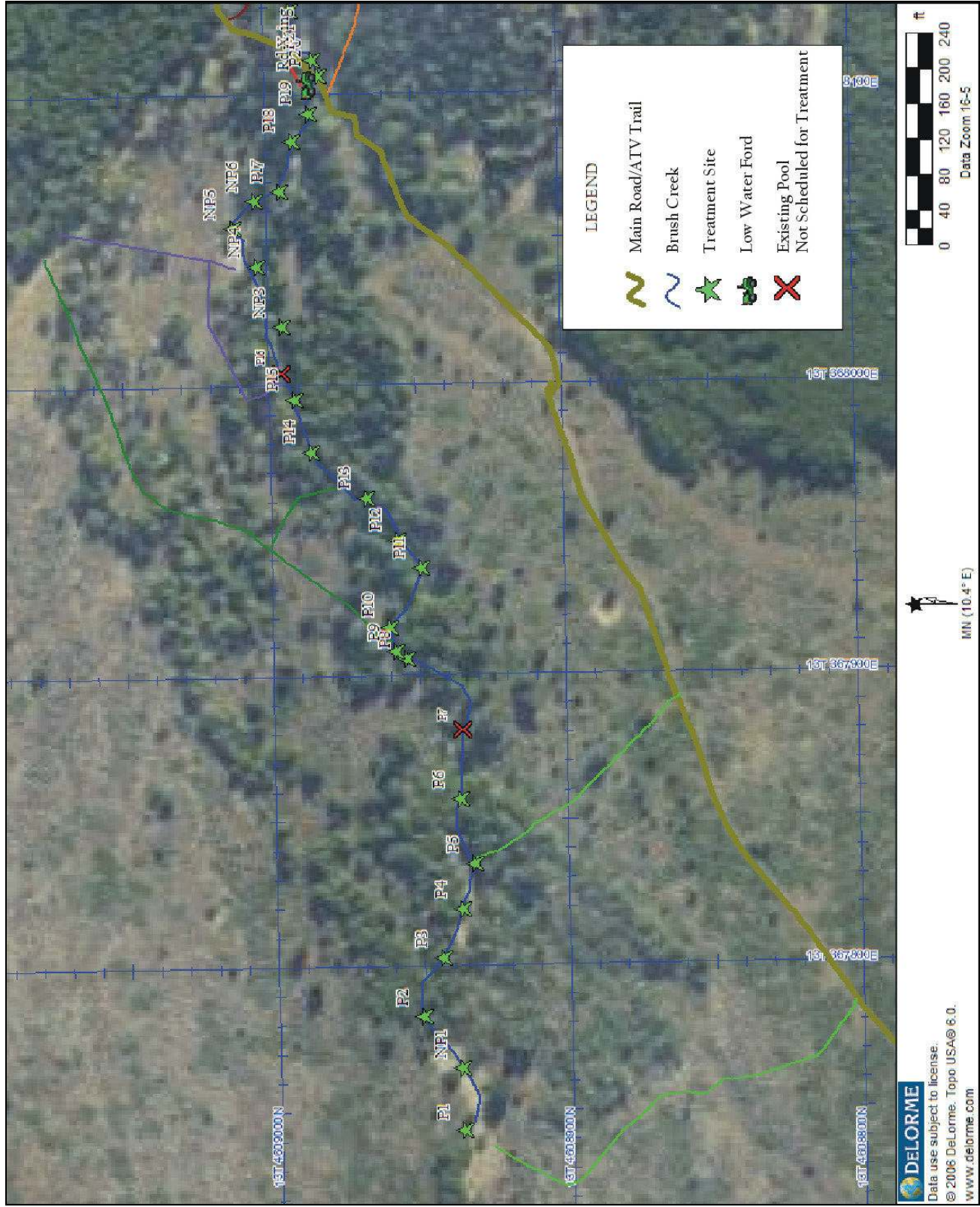
Vicinity Map Showing the Location of the Brush Creek Project



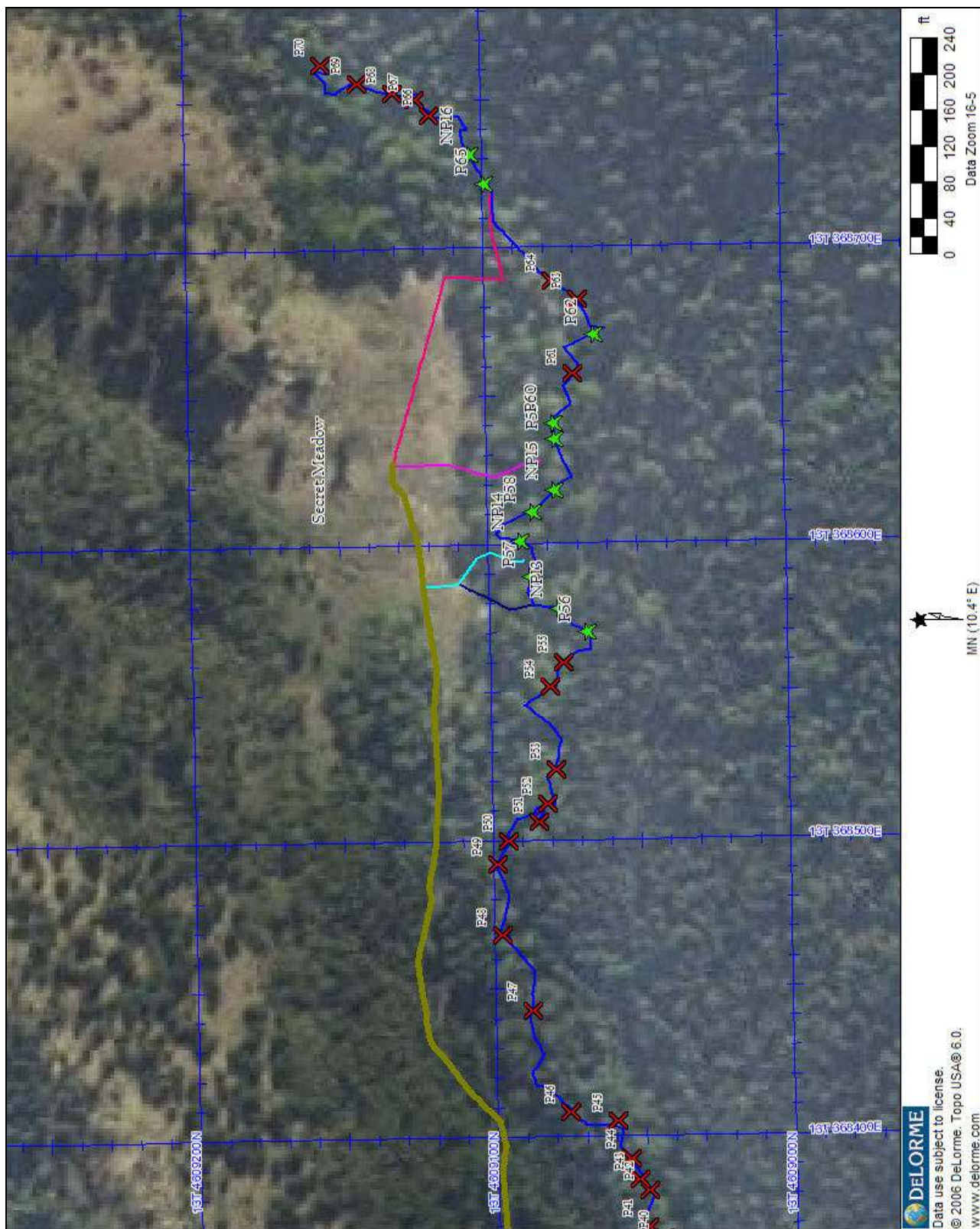
Upper Brush Creek Watershed showing reach delineations and land Ownership

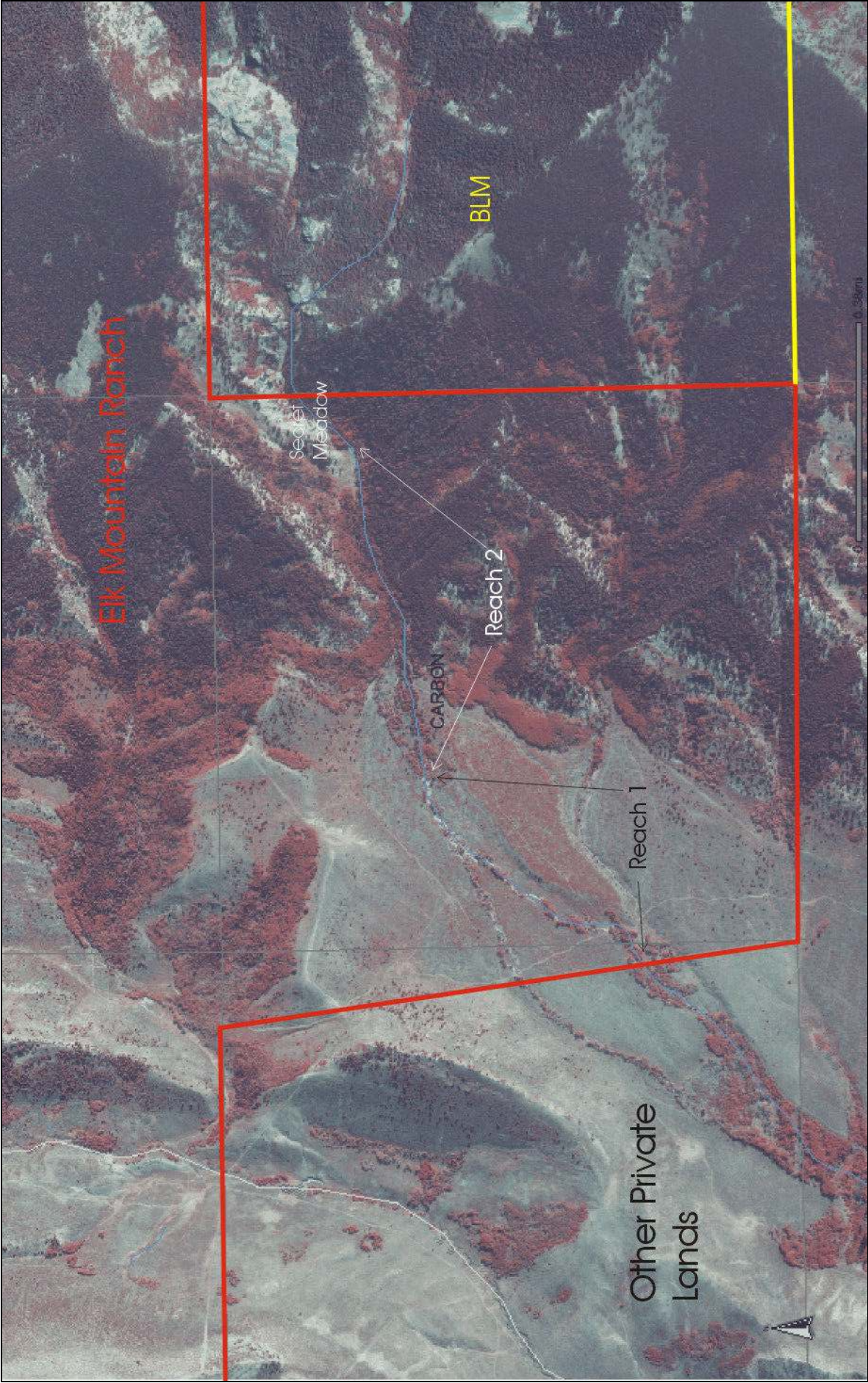


Location of Access Routes to Treatment Sites on Reach 2 of Brush Creek.



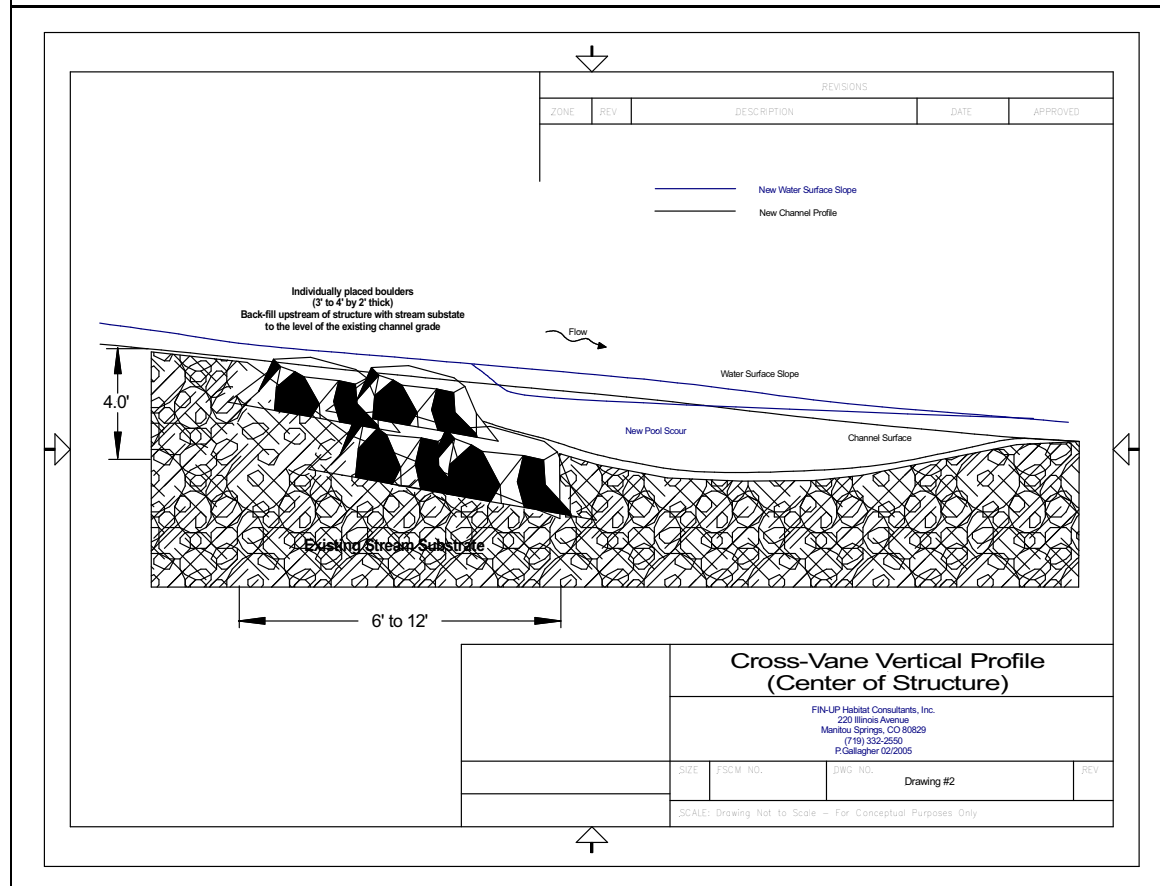
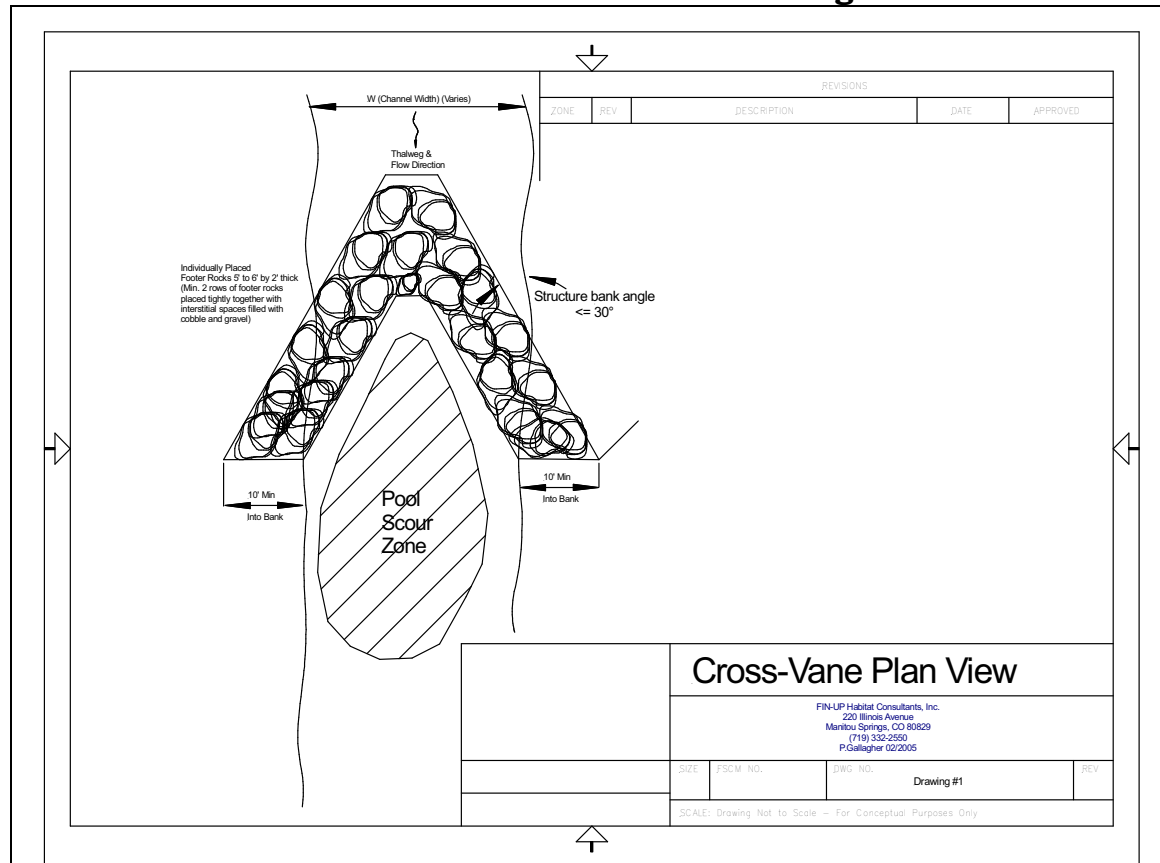
Location of Treatment Sites on the Lower Section of Reach 2 on Brush Creek

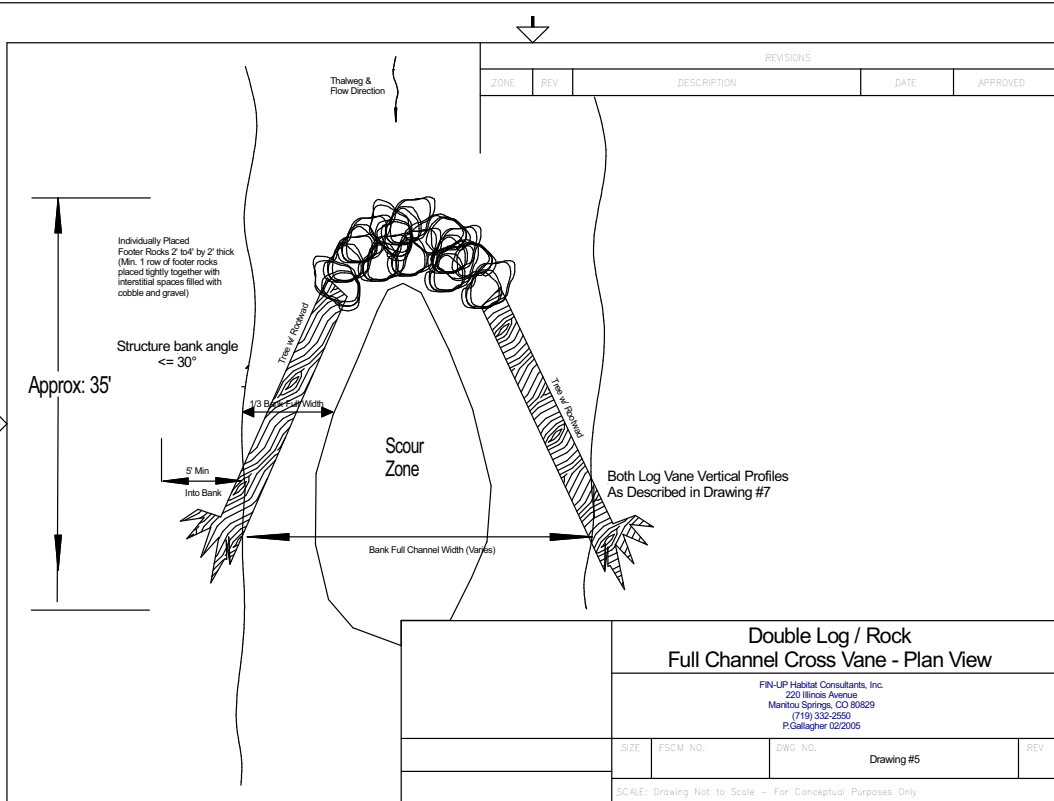
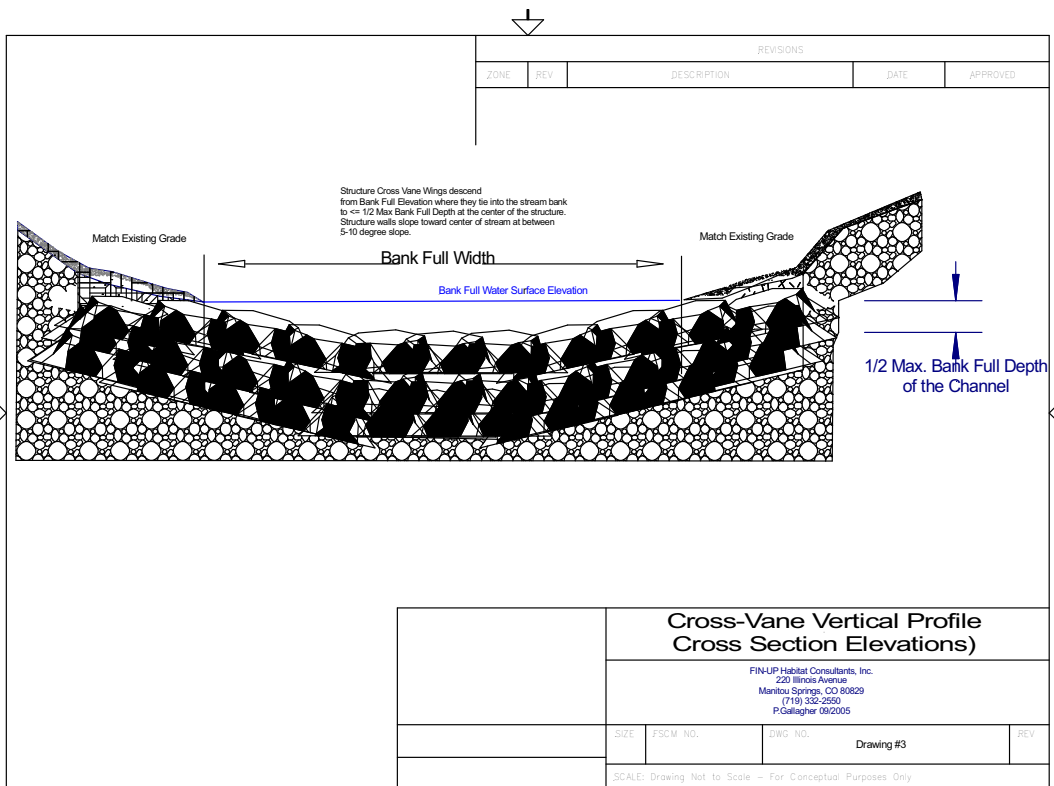


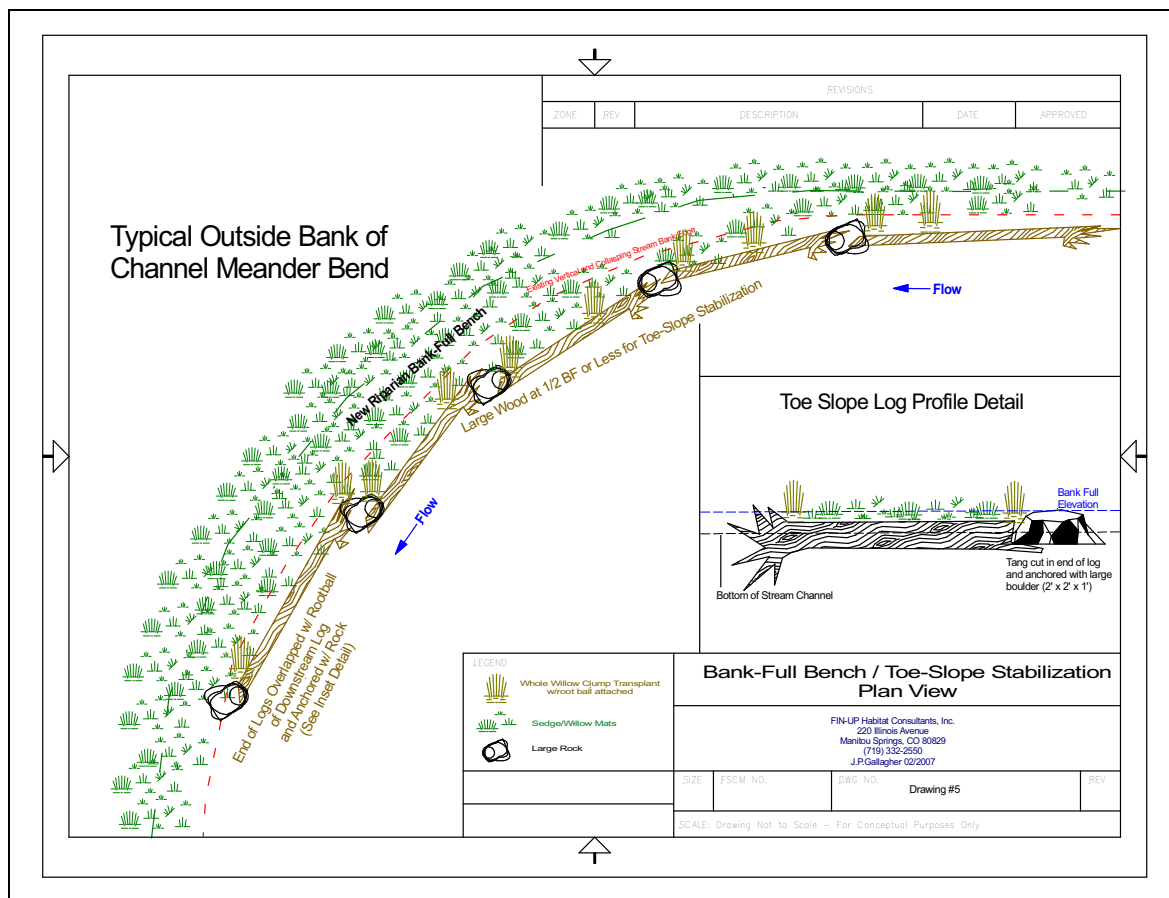
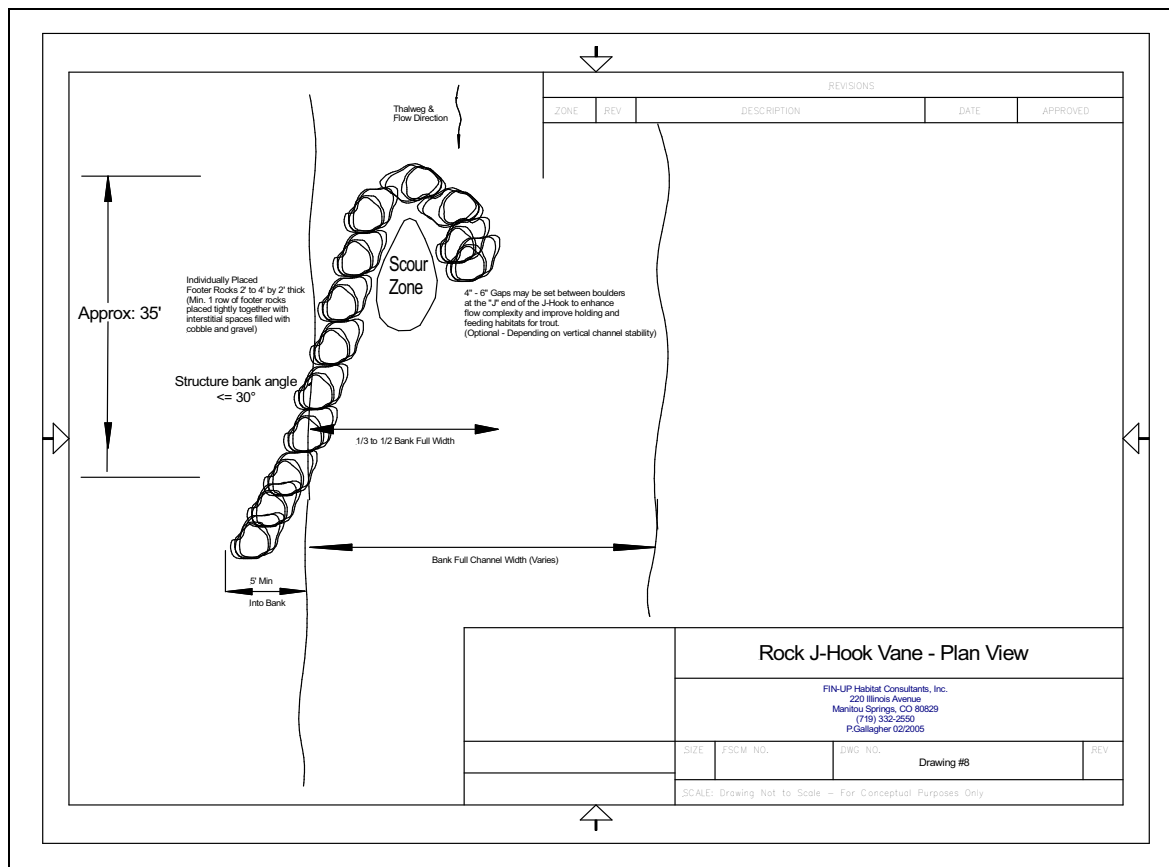


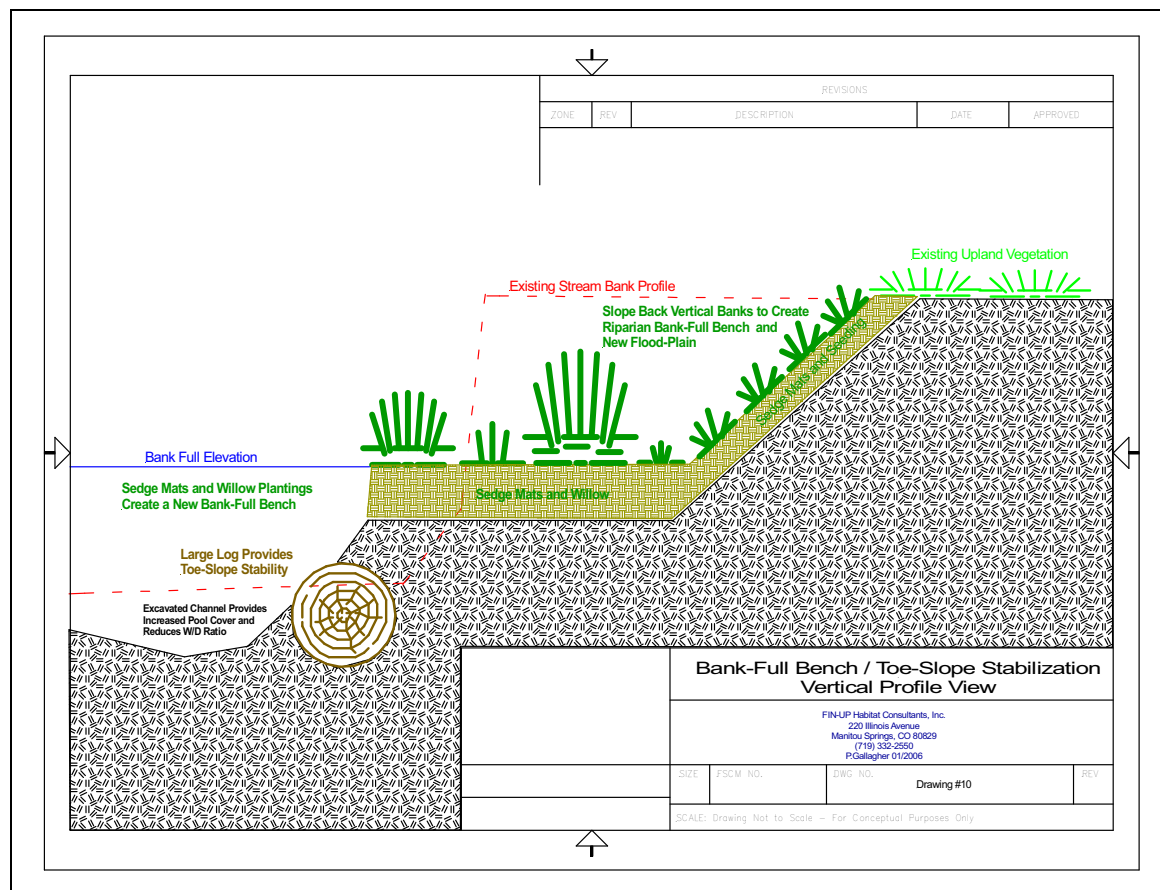
NW1/Color IR Photo of Project Site

Stream Channel Structure and Treatment Drawings



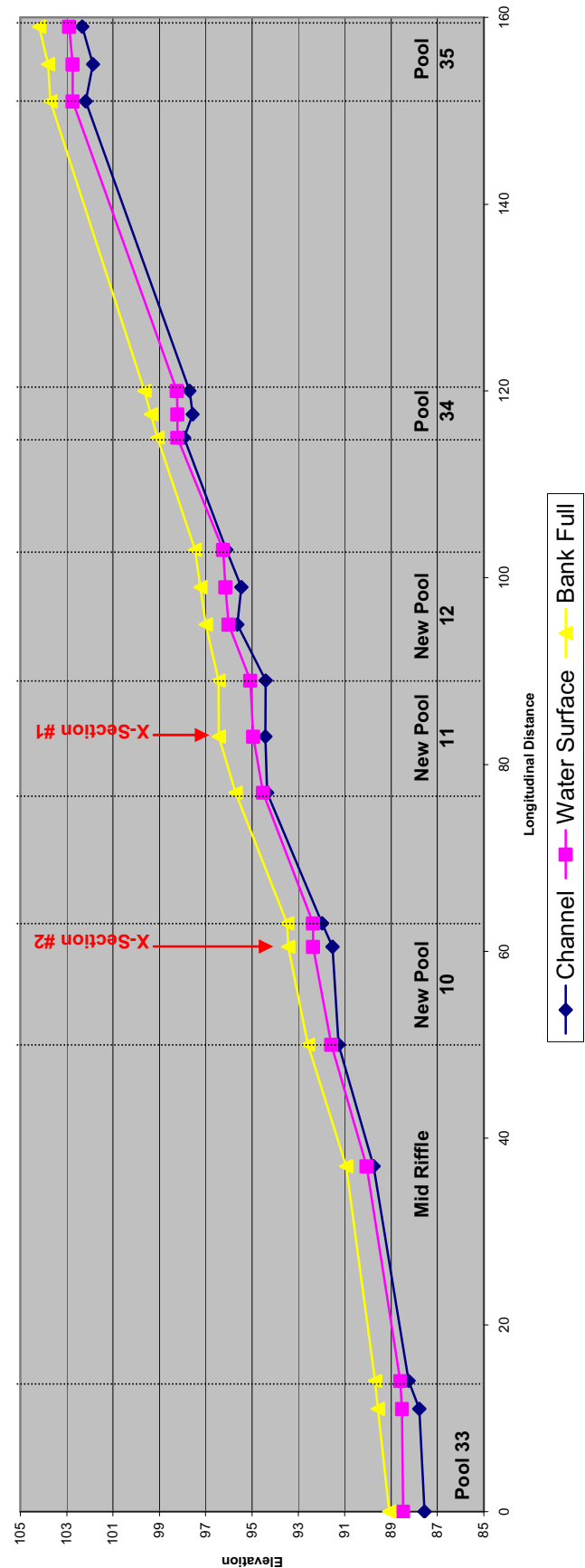




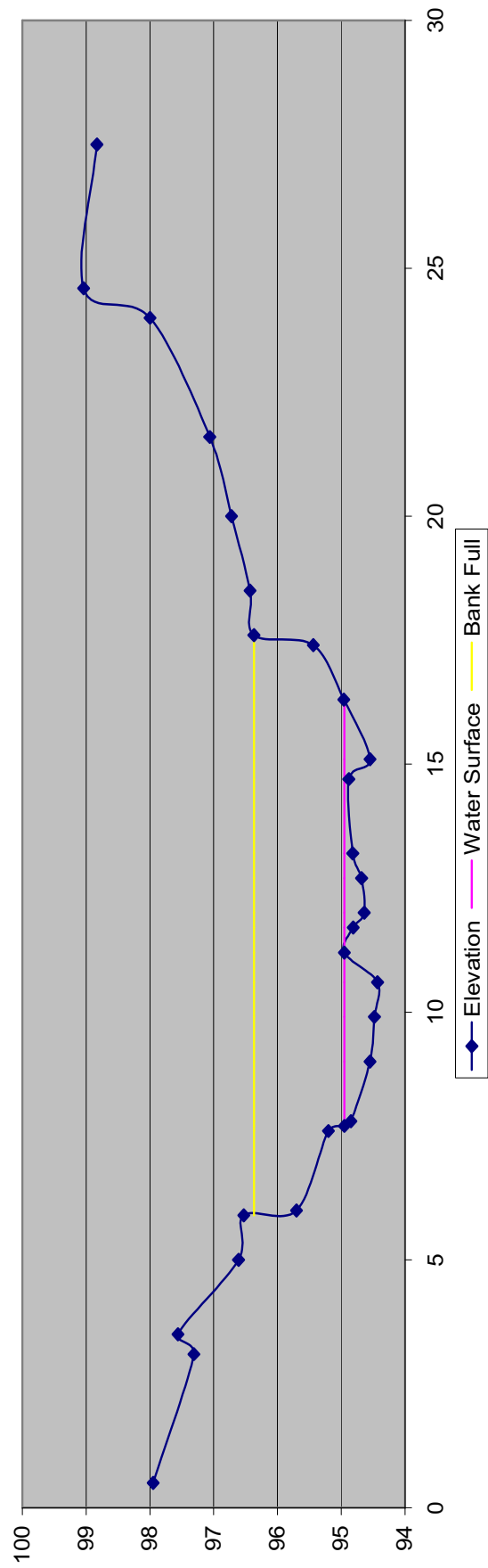


Longitudinal Profile and Cross-Sections

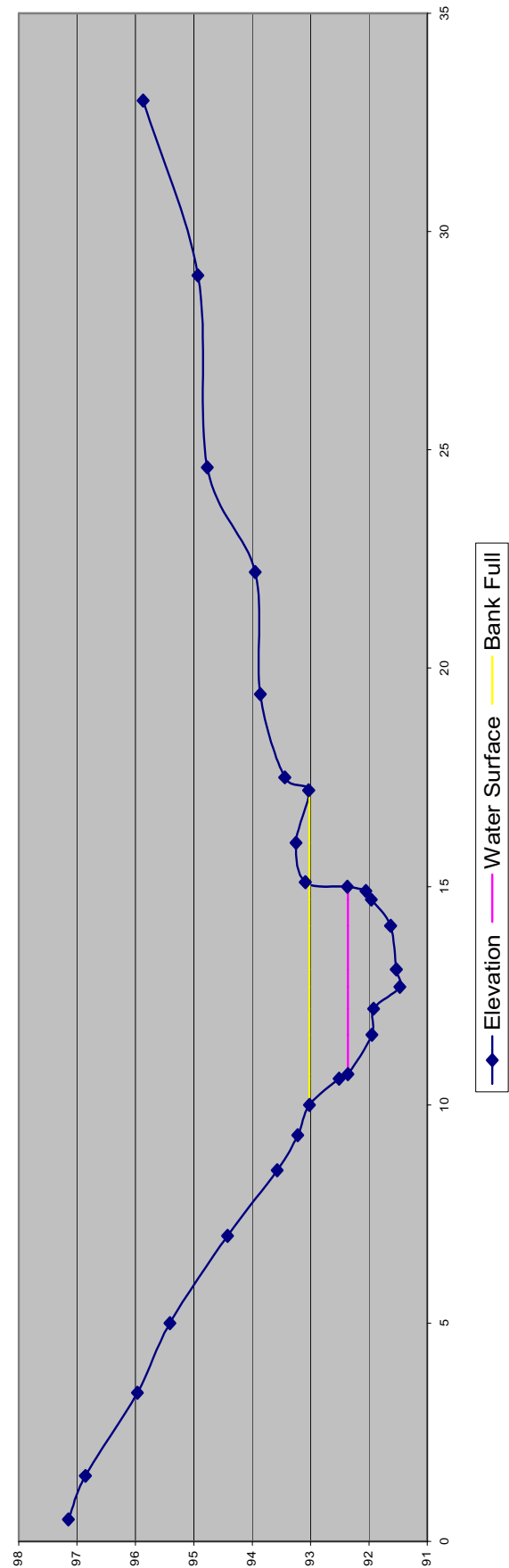
Longitudinal Profile - Representative Sub-Reach of Brush Creek Reach 2



Brush Creek Cross Section #1



Brush Creek Cross Section #2



BASINWIDE STREAM HABITAT SURVEY DATA AND RESULTS (BWSHI)

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