SOUTH PLATTE RIVER RESTORATION PROJECT: HAPPY MEADOWS & SPORTSMEN'S PARADISE

Final Report

2012

PROJECT SUPPORTERS

This project is the result of hard work and committed support from many individuals and agencies.

Our thanks go out to all our partners, including our funding and implementing partners.

Aurora Water Department

Coaltion for the Upper South Platte

Colorado Department of Public Health & Environment 319 Nonpoint Source Program

Colorado Parks & Wildlife

Colorado Water Conservation Board

Denver Water Board

Park County Land & Water Trust Fund

South Platte Enhancement Board

Sportsmen's Paradise

U.S. Forest Service Pike National Forest

Our Contractors:

Fin-Up Habitat Consultants

Crane Associates, LLC

Chapparel Construction

The hundreds of volunteers who helped, including:

Catamount Institute Yes Clubs

Colorado College

Cripple/Creek Victor School

Fountain Valley School

Trout Unlimited — Cheyenne Mountain & Cutthroat Chapters

Special thanks goes to the following Individuals:

With CUSP:

Jonathan Bruno, Carol Ekarius, Lisa Patton, Theresa Springer

With the Pike National Forest

Dana Butler, Denny Bohon, Sara Mayben, Kris Sexton, Mike Welker

With Sportsmen's Paradise

Eric Hendrickson, Dennis Linn, Rob Nuss, Tedd Stiles, Matt Walter and Bob Winckler

All the partners are especially proud of the fact that this project won the U.S. Forest Service's Rise to the Future Award. *This is the top annual recognition that the Forest Service gives to any project around the nation related to aquatic fisheries. This distinction is shared by all those entities, organizations, and individuals who helped make the project happen!*

Note: This publication is available for free on Apple iBooks with interactive features not provided in the PDF version.

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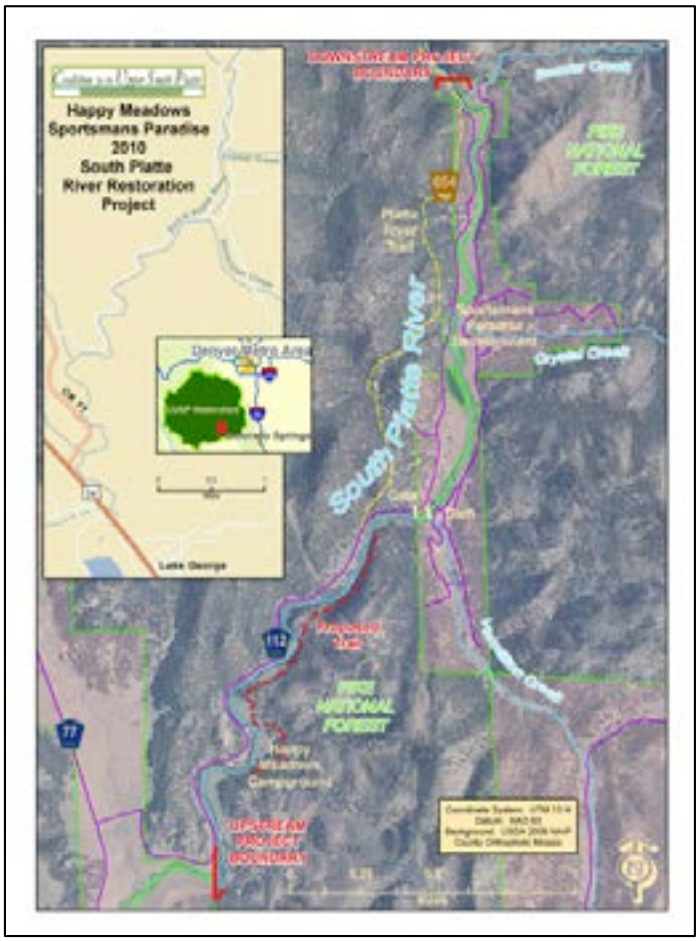
BACKGROUND

The South Platte Habitat Restoration Project worked on both Pike National Forest lands and private lands of the Sportsmen's Paradise HOA. This was a large-scale project that took several years of planning prior to implementation, and due to river flows and regulatory requirements, took two years for implementation. Planning began in 2007. The partners implemented part of the project in August of 2011, and wrapped up the remaining work in September of 2012.

The project begins about 2.5 miles NW of the town of Lake George, Park County, CO, and covers approximately four miles of river. The river is accessible by Park County Road #112, which follows the river throughout the reach on the left (west) bank. The project area is bounded by private property and USFS lands. The upstream reach, designated Reach 22, is located on U.S. Forest Service under management by the Pike & San Isabel National Forests, Cimarron & Comanche National Grasslands, specifically under the management of the South Park Ranger District. The downstream reaches, Reach 20 & 21, are located on private lands immediately downstream of the USFS Happy Meadows Reach. The specific location is seen on the map at right.



The Happy Meadow's/Sportsman's Project was a river restoration and streambank/upland stabilization project that was designed to reduce adverse effects caused by excessive sediment. This segment (designated as 1A of the South Platte River, or COSPUS01A, by the Colorado Department of Public Health & Environment Water Quality Control Division), was identified in Colorado's 303d list of impaired waters that fail to meet water quality standards. In the case of segment 1A, the listing was specifically for failure to meet the State's narrative standard for sediment, which has resulted in the segment's failure to support its "Aquatic Life Cold 1, Recreation 1a, Water Supply, and Agriculture" designations. A planning process that was spearheaded by the State Health Department resulted in the creation of a TMDL, or Total Maximum Daily Load plan, for the river through this area in 2002 to address the elevated sediment pollution; however, the 2002 Hayman Fire, which added significantly increased sedimentation within this stretch, occurred after the TMDL was completed. The TMDL identified roads, campgrounds, picnic areas, livestock grazing, and other disturbed areas as the pre-fire concerns that were causing the river to not meet its water quality targets.

The river area addressed in this project was aggrading, or storing the excessive sediment within the channel. This caused significant channel migration with increased bank erosion, increased bed deposition, loss of substrate habitat (or pebbly and small rock features on the bottom of the channel that are crucial for trout reproduction) and loss of riparian vegetation. Shifting fine and coarse materials were prominent over much of the stream substrate. The area at the boundary of the Forest Service and the private lands was affected by a large low-head diversion structure, or dam, on the Sportsman's Paradise property that caused dramatic overwidening the river and excessive deposition of sediment on the National Forest portion immediately upstream of the dam. It also caused the river to threaten the adjacent road with significant bank failure. Additionally, several large gullies had formed on the large alluvial fans, or natural drainages above the river, on the burned side of the river. These gullies were contributing significant quantities of sediment to the reach, dramatically effecting habitats and water quality throughout the project area.

Overwidening of river, shown above, left, in a pre-project photo. Note on the photo at right, the channel has been narrowed by rebuilding the right bank, and a log and rock j-hook vein concentrates the energy of the river in the middle of the channel to protect the banks.

The project, which was spearheaded by the Coalition for the Upper South Platte (CUSP) and staff of the Pike National Forest. CUSP is a nonprofit watershed group that works in and around the 2,600 square mile Upper South Platte Watershed. We work to bring a wide variety of partners together to complete projects across property boundaries.

This project was designed to:

1. Reduce sediment entering the river.
2. Improve geomorphology so that the river both moves and stores sediment in a more appropriate manner.

3. Improve habitat for fish, benthic community, and other species, including birds and mammals.

4. Increase trout production within this stretch of river.

5. Provide aquatic species passage (currently blocked by the Sportsman's Paradise diversion).

6. Develop restoration design concepts and alternatives that meet broad constituent objectives while meeting environmental goal.

7. Coordinate, with partners, all restoration implementation objectives-environmental goals.

8. Measure the effectiveness of restoration in achieving environmental goals.

9. Account for and report on all project functions.

We accomplished the goals we set forth, and more, but we'll use the words of U.S. Forest Service Regional Aquatic Biologist, Dave Winters (who was not part of the project team) to describe the overall outcome:

Last Friday I drove to Happy Meadows to see the restoration efforts that Pete Gallagher [CUSP's Contractor from Fin-Up Habitat Consultants] and his staff have been working on this summer. It was their last day and I got a tour of the 4.5 mile project that was funded by numerous partnerships. This is the most thought out and successful project of it's kind I have seen. The South Platte River has been damaged throughout most of it's length due to highly fluctuating flows from upstream reservoirs. The result has been an over-wide, sand bed chan-

The channel behind the dam at Sportsmen's caused significant overwidening as seen above left. This threatened the road. Post project (above right), the channel is narrowed through backwater area of old dam, and has a meander bend.

nel with very little habitat for trout and other aquatic animals in this section. In addition to the Forest Service land, a private "Home Association" called Sportsmen's Paradise also received the benefits of this effort. I suspect that in 1 year people will not be able to recognize the changes in stream morphology, revegetation and habitat work that was successfully completed throughout the section. In addition, a channel crossing diversion dam that was blocking upstream movement of fish was removed and barriers were placed to keep vehicles out of the riparian areas. Word has gotten out, as there were several anglers already taking advantage of the work (I saw 3 trout caught while I was there). Anglers are seeking high quality waters like this, and the local economy will no doubt benefit greatly.

Plans are to continue this effort in the historic South Platte River where there was once a train called the "Fish train" that dropped fisherman off throughout it's mountainous length. I've attached a few of the photo's I took, but they really don't do justice to the work that was completed in less than 4 months of actual construction time. It seems like we should have some kind of celebration!

Looking upstream where the dam once blocked the river.

2

PROJECT IMPLEMENTATION

Construction began in early September, 2011, with the removal of the low-head dam & diversion structure at the USFS / Sportsmen's Paradise Property boundary. The dam was removed in segments to limit sediment movement downstream and to maintain the bed elevation upstream. The structure was replaced by three large boulder cross-vanes spanning the full width of the channel along a three hundred foot length of river channel to tie upstream and downstream bed elevations together in a stable form, and to allow for aquatic organism passage through the segment. Once the channel bed sta-

bilization was completed, a new concrete headgate structure was built on the north side of the river immediately adjacent to the upstream most boulder cross-vane. In addition to the headgate structure, 270 feet of 24" HDPE pipe was buried on the left side of the river to connect the new headgate structure with the existing diversion ditch. The new diversion structure effectively delivers up to 10 cubic feet per second (CFS) to the ditch at base river flows of <100 CFS.

Following construction of the new headgate and diversion structure, habitat enhancement and channel realignment work commenced upstream along approximately 1,500 ft of Reach 22, the lower portion of the USFS Happy Meadows reach. The objective of this work was principally narrowing the river where it had become braided and over-widened as a result of sediments accumulating behind the low-head dam. Multi thread channels were closed and bank-full channel width was significantly reduced utilizing large wood and sedge mats to create new river banks throughout this segment. Pre-project width/depth ratios of <100 were reduced to a range of 20-40 within the segment.

Once the short segment of Reach 22 was complete, the crews moved downstream to Sportsmen's Paradise Reach 21, beginning construction of habitat enhancements immediately below the former dam site, and progressing downstream. All of the remaining perennial channel work in Reach 21 was completed on September 29, just before the CPW spawning restrictions went into effect. An additional 4 days were then needed to complete work on the ephemoral draws on the east side of the river in the Happy

Meadows reach (Reach 22).

Top Photo: The dam at beginning of the project. Bottom Photo: New Cross-Vanes below prior dam are used to change elevation across approximately 1500 feet from old dam to existing channel, and to provide flow to the new headgate (photos on next page).

Construction of new headgate top two photos. New headgate at left.

stream. All of the remaining perennial channel work in Reach 21 was completed on September 29, just before the Colorado Parks & Wildlife (CPW) seasonal spawning restrictions went into effect. An additional 4 days were then needed to complete work on the ephemeral draws on the east side of the river in the Happy Meadows reach (Reach 22). Following the end of the spring trout hatchling restriction period in early June of 2012, the project recommenced with construction of habitat and channel features in the lower Sportsmen's Paradise Reach 20. As was done in the previous year, work began at the upstream boundary and progressed downstream. Reach 20 was completed in one month of work, with several delays due to high fire danger in the region that summer. Fortunately all in-channel work was completed before the Cities of Denver and Aurora need to move additional water downstream.

The final phase of construction, through the upper portion of Happy Meadows Reach 22, was undertaken at the beginning of September, 2012. By this time, fire danger had subsided in the region, and ideal flows of 70 – 90 CFS allowed for rapid completion of the remainder of the project. The remaining 2 miles of river restoration was completed on September 29, 2012, with equipment demobilized the following day.

A backwater pond created where the channel used to split provides habitat for birds, amphibians, mammals, and insects.

3

PROJECT ACCOMPLISHMENT

Over a period of slightly more than one year, over 4 miles of the South Platte River were enhanced for improved trout habitat and sediment transport. A significant barrier to aquatic organism passage was removed from the river, and a new “fish passage friendly” diversion structure installed in its place. In-channel habitat enhancements included incorporation of large wood into the channel in the form of log vanes, habitat trees, and bank full riparian benching. Boulder cross vanes, J-hook vanes and groins were installed to provide increased channel bed stability, velocity shelter, and habitat

complexity to the system. More than 1 ½ miles of river bank was realigned through bank full benching, sedge matting, and other bank treatments to effectively narrow the river, improving sediment transport and pool scour. Additionally, two major ephemeral draws on the east side of the river within the Hayman burn scar, were treated utilizing log "rock&roll" structures and other techniques to cut off the sediment supply to the river from these sources.

For the most part, construction followed the design outlined in CUSP's South Platte River Sportsmans Paradise & Happy Meadows River Assessment & Restoration Plan, 2011. Minor deviations from the plan were necessary from time to time due to changes in conditions between the time of the assessment (2006 – 2010) and implementation of the work in 2011 & 2012. For example, a few of the river banks identified early in the assessment as degraded or eroding had begun to recover before the project commenced in 2011. In this case, if the river bank was deemed to be recovering with a sufficient upward trend toward desired condition, we elected to leave the bank "as-is" rather than creating potential instability and disturbance as a result of construction activities.

The table below lists the habitat and channel features installed during the course of the project.

Treatment Type	Reach 20	Reach 21	Reach 22	Total
Full Channel Boulder Cross Vane	7	7	6	20
Full Channel 2x Log/Boulder Cross Vane	2	2	6	10
Boulder J-Hook Vane	5	5	11	21
Log/Boulder J-Hook Vane	9	9	15	33
Boulder Vane / Groin	1	6	3	10
Boulder Cluster	19	-	25	44
Habitat Tree	15	4	19	38
"Lunker" Cover Structure	-	-	2	2
Log "Rock & Roll" Vanes	-	-	14	14
Bank Full Riparian Benching in Feet	2,650	2,300	3,600	8,550
Total Large Wood (whole trees)	105	95	200	400

SOME THINGS CHANGE

There were four significant changes from the original design during the course of construction. Three changes were necessary in the Happy Meadows Reach 22, and one in Sportsmen's Paradise Reach 21. These changes, are documented below.

Treatments in the minor ephemeral draws entering the South Platte River from the southeast near the upstream boundary of Happy Meadows were dropped from the project due to the close proximity of a cultural heritage site to the construction area. Upon review with the USFS forest archeologist and forest hydrologist, we determined that the work could not be completed without significant disturbance to the historic site. Further assessment of the ephemeral draw upstream of the site indicated that the channel had down-cut to bedrock and was now stable, and would likely not continue to contribute excess sediment to the river. Additionally, the two habitat trees planned for the main-stem channel immediately upstream of this draw were dropped from the project because we could not get equipment past the cultural site to harvest the trees.

The original design called for closing the secondary channel on the west side of the river near the upstream boundary of Happy Meadows Reach 22. This would require re-alignment of several large boulders in the main channel near the upstream confluence of the 2nd channel in order to reduce near bank stress along the newly constructed channel closure. Unfortunately, these boulders have characteristics more akin to icebergs, and were too large for the equipment to move. After consultation with the USFS forest hydrologist, the design was altered to keep the 2nd channel. Two channel-spanning boulder cross vanes were added to the 2nd channel to maintain bed elevation, preventing the river from eventually migrating into this feature

Two large full channel boulder cross vanes were dropped from the project in Happy Meadows Reach 22. These structures, one near Happy Meadows Campground, and the other near the Platte Springs trailhead were initially proposed in conjunction with foot bridges that would allow for construction of a new trail system on the east side of the river. The primary function of these cross vanes would be to provide protection for the bridge abutments and to provide fish-viewing opportunity for recreation users. Funding for the bridges was never se-

cured, and the new trail was eventually dropped from consideration for the current project. This trail and bridge system may be developed at some future date, and if so, these structures will need to be considered as part of the planning for the project at that time.

The large island immediately downstream of the existing roadway bridge near the upstream boundary of Sportsmen's Paradise was not removed due to the specific request of several members of the Sportsmen's Paradise Home Owners Association. This may have a very minor effect on sediment transport through this segment, but this area provides easy fishing for handicapped and youth anglers within their community.

As-built drawings have been completed for the project, and are included in the appendix at the end of the document. The as-built drawings begin at the upstream boundary of the project at the Happy Meadows USFS / private property boundary, and progress downstream through the Sportsmen's Paradise dam site to the downstream boundary of the project, immediately below the confluence of Beaver Creek and the South Platte River at the northern Sportsmen's Paradise / USFS property boundary.

Photos: Cross vane reconstruction in Reach 20 before project & after project.

4

PROJECT MONITORING

For larger projects such as this, monitoring is an essential element from start, to finish, and beyond. Early monitoring is required for developing the plan. Initial post-project monitoring helps establish that the project was completed as intended. Finally, long-term monitoring provides a vehicle for continued learning and adaptation on future projects. These functions assure funders, government leadership, and area residents and visitors that this project, and others in the future, are worth the investment. The project reaches were and will be monitored to determine how proposed treat-

ments affect stream stability and habitat compared to pretreatment conditions.

To measure the effectiveness of the proposed treatments for reducing sediment impacts, the monitoring objectives will seek to answer the following:

1. Did the percentage of unstable stream bank decrease after treatments?
2. Did the width to depth ratio of the stream decrease after treatments?
3. Did percentage of fine sediment decrease after treatments?
4. Did pool habitat increase after treatments?
5. Did stream stability ratings improve after treatment?
6. Did the percentage of stream bank with vegetation cover increase after treatments?
7. Did sediment transport capacity change after treatment?
8. Did benthic macro-invertbrate (insects that trout depend on for supper) abundance and diversity increase after treatments?

We began pre-project monitoring in 2009. As environmental education is an important aspect of CUSP's mission, and is generally supported by the federal and state agencies we work with, we started the planning process by including students from the Woodland Park High School's Environmental Science class (primarily juniors and seniors) in initial assessment work.

Pre-Project Monitoring

The students assisted U.S. Forest Service and Colorado Parks & Wildlife aquatic biologists and hydrologists with gathering data that was necessary for the NEPA (National Environmental Policy Act) process, which is a planning-process step that must completed prior to working on federal lands, or to using federal funds on a project. As we would be doing both, the NEPA process was required.

Students helped the team as they gathered field data, including fish numbers, width to depth ratios, meander frequency, and vegetation data.

Our goals for this project included working with students in part so they would learn about:

1. How human activities—such as recreation, roads, livestock grazing, etc.—impact the ecosystem;
2. How to read USGS maps and use GPS units to gather data;

Students collecting cross-section data with U.S. Forest Service personnel.

A student collecting and recording mapping data.

3. How to identify species that indicate ecosystem health;
4. About what interventions must be used to correct ecosystem problems, such as sediment loading in rivers and invasive species on land; and
5. How to translate the data that they collected in the field into 3-dimensional scaled-relief models by completing a model of a specific natural area within the USFS Pike National Forest.
6. We also had the students present their findings to the public and stakeholders as part of the public scoping process.

The students learned these lessons, and more importantly, they learned life lessons they will carry with them in the future. Teacher Kendall Hovel of Woodland Park summarized it well in a follow-up email he sent to Congressman Doug Lamborn's staff member, John VanderMeulen (and cc'd us on). VanderMeulen attended the students' presentation for area elected officials, school officials, and other partners:

Thank you for attending the environmental science presentation on Wednesday. I'm sorry I didn't get a chance to speak with you before you had to leave, but I thought you posed an important question to the students, and I didn't feel you received a sufficient answer. It is an important question because these experiences can be 'fun,' as the students said, but if they aren't learning, then it does not have educational value. All too often we hear the phrase 'hands-on learning' when really what we are striving for is minds-on learning. I am convinced, however, that hands-on is a reliable way to achieve minds-on.

The students you saw Wednesday are not honors students. Some of them are just one bad choice away from expulsion or alternative education. They have come a long way this year, in large part because of this project. While it would have been nice if the students had responded to your question with some pro-

found thoughts about hydrology or aquatic ecosystems or wildlife, I think the most valuable learning that took place will actually be realized in years to come. As their teacher I want them to learn about hydrology and biology, but I see the most valuable product of this project as the process the students went through. Students were guided through field investigations by professionals who conduct these studies on a daily basis.

Students present their findings during a scoping meeting to elected officials, school board members, government officials, and impacted residents.

They learned how to apply the scientific process in a new setting, which they were not familiar with. This is not important because I expect them all to enter into scientific careers where they can apply this experience directly, but because problem solving is so much like the scientific process that we could say they are one in the same. I expect every student in my class to encounter unfamiliar problems in their future, which they will need to solve. When the students who participated in the Happy Meadows project encounter problems in the future I expect them to have a sense that they can solve the problem and how they should go about it because they have 'been there and done that.'

The presentation itself was part of the learning process for them. I was reassured of this yesterday when I asked a student how he thought it went. This student had given me attitude the day before the presentation when I hassled him about preparing. When I asked him on Thursday how he thought it went, he humbly answered, 'I think I could have been more prepared.' Questions from professionals like yourself, which put them on the spot, helped them evaluate their own level of understanding, which is a skill I ultimately want them to have when they leave my class. Though it wasn't apparent Wednesday, I expect next time these students make a presentation they will be more prepared and professional without me having to hassle them to do so.

Again, thank you for making the effort to attend. I hope it was a valuable experience for you because I know it was for the students and myself.

Of course, not all monitoring was done by students. In 2008, 2009, and 2010 staff of CUSP, the Pike National Forest, and our contractors also collected per-

tinent pre-project data. Earlier monitoring data in these reaches was also gathered and reviewed.

Aquatic monitoring has been conducted by the US Forest Service throughout the Happy Meadows Reach 22, including basinwide aquatic habitat inventories (1993 & 2002), and extensive channel morphology surveys in 2006 and 2008. In 2009 and 2010, a rapid aquatic habitat and existing structure assessment and a channel morphology survey was conducted within the Sportsman's Paradise reaches by FinUp Habitat Consultants, Inc., and Crane Associates, contractors to CUSP, with assistance from a US Forest Service hydrologist, and volunteers from Sportsmen's Paradise. This information was utilized to develop the habitat assessment and enhancement plan.

Low gradient riffles were the dominant mesohabitat form in the Sportmen's reach 20, and comprised 46% of the wetted area of the reach. Pool habitats occupied 34% of the reach, with the remaining 20% comprised of poorer quality glides. Glide habitats were typically associated with disturbed areas and segments where previous habitat enhancement attempts had been undertaken by residents. River bank rock composition (BRC) was heavily dominated by gravel or smaller sized particles consisting mostly of decomposed granite. Given the composition of BRC in the reach, the stream banks in Reach 20 were relatively stable and well vegetated with sedge and willow. 12% of the east (right) river banks and 5% of the left (west) banks exhibited some signs of instability, and 330 feet of bank was found to be actively eroding materials into the river.

In Sportsman' Paradise Reach 21, low gradient riffles were once again the dominant mesohabitat form in the reach, and comprised 51% of the wetted area of the reach. Pool habitats were less frequent than in Reach 20, and occupied only 25% of the reach, with the remaining 24% comprised of poorer quality glides. As was the case in Reach 20, glide habitats were closely associated with disturbed areas. BRC was almost entirely dominated by gravel or smaller sized particles consisting decomposed granite. The stream banks in Reach 21 exhibited similar stability and vegetation characteristics to the reach downstream, and were relatively stable and vegetated with sedge and willow. 7% of the east (right) river banks and 15% of the left (west) banks exhibited some signs of instability, and 200 feet of bank was found to be actively eroding materials into the river. Most of the unstable left bank was directly associated with the fill slope forming the diversion ditch that feeds the lake on the west side of the reach.

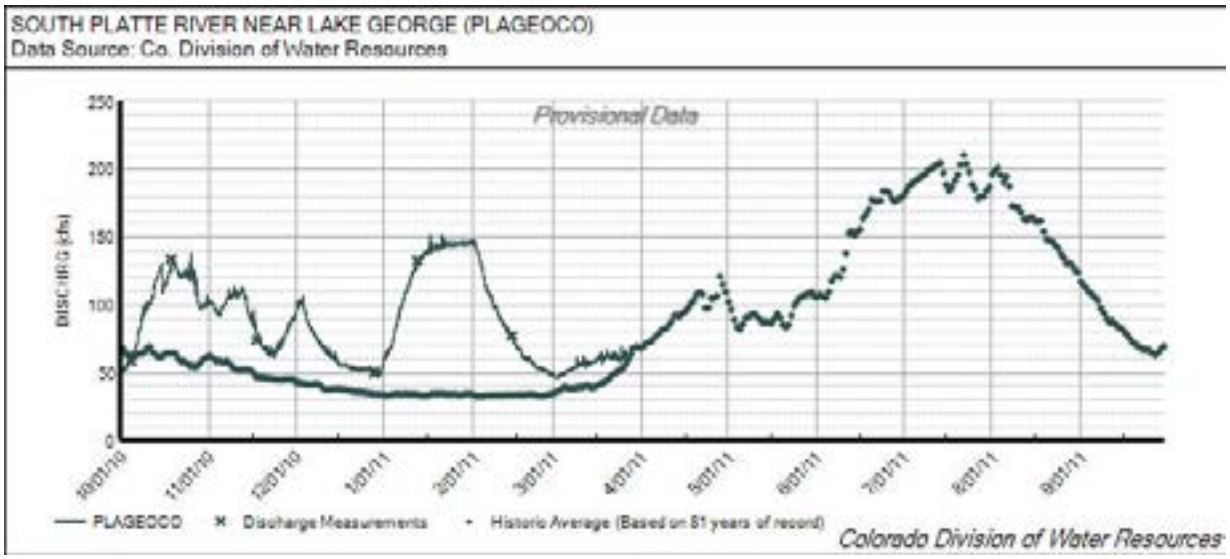
Within Happy Meadows Reach 22, low-gradient riffles were once again the

dominant mesohabitat form in the reach, and comprised 51% of the wetted area of the reach. Pool habitats occupied 21% of the reach, with the remaining 28% comprised of poorer quality glides. River bank rock composition (BRC) was heavily dominated by gravel or smaller sized particles consisting mostly of decomposed granite. Given the composition of BRC in the reach, the stream banks in Reach 20 were relatively stable and well vegetated with sedge and willow. 16% of the east (right) river banks and 28% of the left (west) banks exhibit some signs of instability, and 2,950 feet of bank was found to be actively eroding materials into the river.

Hydrology & HEC RAS

The hydrology for the South Platte River at Happy Meadows was evaluated using stream gage information to perform a flood frequency analysis. Annual maximum flows were determined from the monthly peak discharge information available for the South Platte River near Lake George (PLAGEOCO) gage operated by the Colorado Division of Water Resources.

The gage is located at latitude 38 54'19" and longitude 105 28'22", on the left bank approximately 700 feet downstream of Eleven Mile Canyon Reservoir.



Example data set from Colorado Division of Water Resources for the gage at Lake George.

The contributing drainage area at the gage is 963 square miles and the gage has been operated continuously since October 3, 1929. However, the Eleven Mile Canyon Dam construction was completed in 1932, therefore the period of record used for analysis for this project is the post-dam period, 1932 to 2009.

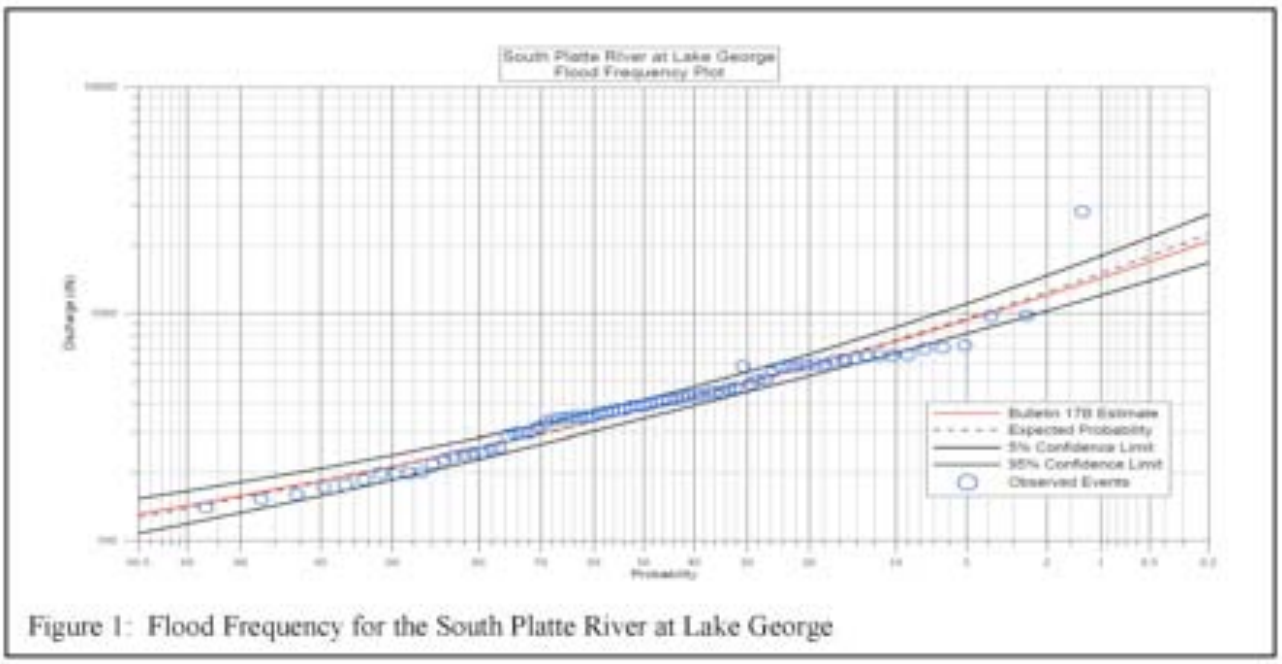


Figure 1: Flood Frequency for the South Platte River at Lake George

This program is based on the methods outlined in “Guidelines for Determining Flood Flow Frequency, Bulletin 17B of the Hydrology Subcommittee” of the USGS. This method utilizes a Log Pearson Type III distribution with a regional and station-weighted skew to evaluate peak flow data and perform the frequency analysis. The results of the analysis at the gage are summarized in Table 1 and shown in Figure 1 (next page).

The results are representative of flows at the gaging station. However, this is approximately 12.5 miles upstream of the project site. To determine flows at the Happy Meadows project, the following equation was applied: QT(u) = QT(g) (Au/Ag)x

Where QT(u) is the peak discharge in cfs at the ungaged station for the T year recurrence interval

QT(g) is the peak discharge in cfs at the gaged station for the T year recurrence interval

Au is the contributing drainage area for the ungaged station

Ag is the contributing area for the gaged station

X = the average exponent for drainage area for each flood region,

= 0.69 for the Mountains region

The equation and methodology are described in the USGS WaterResources Investigation Paper 994190 titled “Analysis of the Magnitude and Frequency of Floods in Colorado”.

Frequency Analysis Results for PLAGEOCO 1934-2009			
Percent Chance Exceedance	Computed Flow (cfs)	Confidence Limits 0.05	0.95
		Flow in cfs	
0.2	2072	1671	2731
0.5	1686	1389	2157
1	1429	1198	1787
2	1199	1023	1464
4	992.5	862	1182
10	750.4	667.2	864.2
20	585.4	528.9	657.6
50	377.6	343.5	414.6
80	255.2	226.8	282.7
90	211.6	184.6	237.3
95	183	157	207.5
99	142.2	118.2	164.9

Area Gaged = 963 mi^2
Area Ungaged = 1145 mi^2
A_U/A_G = 1.19
$Q_T(u) = Q_T(g) (A_U/A_G)^{0.69}$

Frequency Analysis Results for Happy Meadows Site		
Percent Chance Exceedance	Return Period (yrs)	Predicted Flow in cfs
0.2	500	2,335
0.5	200	1,900
1	100	1,610
2	50	1,351
4	25	1,118
10	10	846
20	5	660
50	2	426
80	1.25	288
90	1.11	238
95	1.05	206
99	1.01	160

Table 1: Flood Frequency Analysis Results for the PLAGEOCO gage andHappy Meadows Project Site

A HEC RAS sediment transport model has been developed for the project to verify the sediment transport goals of the design. HEC RAS prediction modeling is included in the Appendix.

Pre-project monitoring also included establishment of permanent cross-section analysis points (as seen in the map, lower left) that will be used for WARSSS and Hec RAS additional analysis in the future.

Benthic Macroinvertebrate Sampling

Benthic macroinvertebrate sampling was conducted by USFS personnel at three sites within the project reaches in September 2011. The sample sites consisted of cobble/gravel riffle habitats, and were sampled using a Hesse sampler with either a 50/50 or 33/33/33 sample split. Sample station SOPLAT01 was located near the upstream boundary of the project area. Sample station SOPLAT02 was located in the vicinity of the low head dam at the USFS / Sportsmans Paradise west property boundary, and sample station SOPLAT03 was located immediately upstream of the foot bridge at the Reach 20 / Reach 21 boundary in Sportsmans Paradise. A map of the sampling sites is shown on page 26.

Samples were sorted and analyzed by the BLM BugLab at Utah State University in Logan UT. Samples were assessed for species composition, abundance, density, and richness. A standardized species matrix present in the three sites is shown in the table below.

HAPPY MEADOWS / SPORTSMANS PARADISE PROJECT - SOUTH PLATTE RIVER 2011					SAMPLE STATION		
Phylum	Class	Order	Family	OTUName	SOPLAT01	SOPLAT02	SOPLAT03
				Turbellaria	0	39	166
Annelida				Other_Oligochaeta	124	0	189
Arthropoda				Acari	124	0	331
Arthropoda	Insecta			Lepidoptera	136	79	674
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	548	51	3146
Arthropoda	Insecta	Coleoptera	Elmidae	Zaitzevia	249	79	166
Arthropoda	Insecta	Diptera		Simuliidae	27709	7052	26358
Arthropoda	Insecta	Diptera	Athericidae	Atherix	0	0	166
Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogoninae	0	0	331
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	0	39	331
Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	17147	12092	35429
Arthropoda	Insecta	Diptera	Psychodidae	Maruina	0	0	166
Arthropoda	Insecta	Ephemeroptera	Baetidae	Acentrella	2248	1631	2980
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	5863	4396	13410
Arthropoda	Insecta	Ephemeroptera	Baetidae	Plauditus	2621	158	6126
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Serratella	0	39	0
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	Tricorythodes	1615	0	6645
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Choroterpes	249	0	12
Arthropoda	Insecta	Plecoptera		Chloroperlidae	249	0	0
Arthropoda	Insecta	Plecoptera	Perlidae	Claassenia	35	0	0
Arthropoda	Insecta	Plecoptera	Perlodidae	Skwala	12	0	0
Arthropoda	Insecta	Trichoptera		Helicopsyche	124	0	0
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	0	39	1490
Arthropoda	Insecta	Trichoptera	Brachycentridae	Micrasema	0	0	166
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Culoptila/ Protoptila	1988	0	331
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	124	0	0
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	1600	338	2199
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	124	0	331
Arthropoda	Insecta	Trichoptera	Leptoceridae	Oecetis	497	0	331
Mollusca	Gastropoda	Basommatophora		Physa_Physella	0	0	166

STATION (NAMC)	SOPLAT01	SOPLAT02	SOPLAT03
Area sampled (m^2)	0.26	0.18	0.26
Field Split	33	50	33
Lab Split	9.38	28.13	7.04
Split Count	613	716	670
Fixed Count	300	300	300
Big Rare Count	44	19	13
Richness*	17	8	20
Abundance	76680	28493	111073
Shannon's Diversity*	1.669756934	1.342617463	1.990509828
Simpson's Diversity*	0.716343367	0.681939799	0.805774805
Evenness*	0.589350935	0.645662518	0.664448504
# of EPT Taxa*	11	4	10
EPT Taxa Abundance	27041	7837	41470
Dominant Family	Simuliidae	Chironomidae	Chironomidae
Abundance of Dominant Family	29945	12447	36091
Dominant Taxa	Simulium	Orthocladiinae	Orthocladiinae
Abundance of Dominant Taxa	27709	12092	35429
Hilsenhoff Biotic Index*	5.206666667	5.453333333	5.043333333
# of Intolerant Taxa*	3	0	5
Intolerant Taxa abundance	9366	118	4647
# of Tolerant Taxa*	0	0	1
Tolerant Taxa abundance	0	0	166
USFS Community Tolerance Quotient (d)*	79	88	78
# of shredder taxa*	2	1	3
Shredder Abundance	124	0	497
# of scraper taxa*	3	1	4

An important point to note regarding the species matrix found in the sites include the absence of New Zealand Mud Snails (NZMS). NZMS have been identified as a noxious and exotic nuisance species in Colorado, and are present in the South Platte River a few miles upstream of the project reaches in Elevenmile Canyon. Also, the samples appear to be dominated by filter feeders, which may indicate a nutrient issue previously unidentified from upstream (Winters, personal communication, 2013). A functional feeding analysis (Merrit & Cummims, 1996) may be necessary following the first post-project sampling effort to validate this concern.

STATION (NAMC)	SOPLAT01	SOPLAT02	SOPLAT03
Scraper abundance	6287	288	10938
# of collector-filterer taxa*	3	2	3
Collector-filterer abundance	32912	8496	34351
# of collector-gatherer taxa*	5	3	6
Collector-gatherer abundance	35572	19342	62803
# of predator taxa*	2	0	3
Predator abundance	668	0	1159
# of clinger taxa*	8	2	8
Long-lived Taxa*	2	1	3
# of Ephemeroptera taxa*	5	3	4
Ephemeroptera abundance	20424	7014	31490
# of Plecoptera taxa*	0	0	0
Plecoptera abundance	792	0	0
# of Trichoptera taxa*	6	1	6
Trichoptera abundance	5825	823	9980
# of Coleoptera taxa*	2	1	2
Coleoptera abundance	1914	130	4636
# of Elmidae Taxa*	2	1	2
Elmidae abundance	373	39	1821
# of Megaloptera taxa*	0	0	0
Megaloptera abundance	0	0	0
# of Diptera taxa*	2	2	6
Diptera abundance	47341	20408	63442
# of Chironomidae taxa*	1	1	2
Chironomidae abundance	17396	12447	36091
# of Crustacea taxa*	0	0	0
Crustacea abundance	0	0	0
# of Oligochaete taxa*	0	0	0
Oligochaete abundance	124	0	189
# of Mollusca taxa*	0	0	1
Mollusca abundance	0	0	166
# of Insect taxa*	16	8	19
Insect abundance	76432	28453	110222
# of Non-insect taxa*	1	0	1
Non-insect abundance	249	39	851

It is not unsurprising to see that diversity, abundance and richness appear to be depressed in sample site SOPLAT02 in the immediate vicinity of the low head dam. We expect to see significant change in this station in the next post project sampling effort, due to the elimination of sediment deposition behind the dam and return of the segment to a more natural cobble and gravel dominated riffle. Detailed descriptions of each of the assessment metrics in the previous table are listed in the table on the following pages.

*Standardized to OTU and fixed count. Common metrics used to assess freshwater biological integrity, as well as basic field and lab processing information. Note that values for richness based metrics are standardized to operational taxonomic units (OTUs; sensu Cuffney et al. 2007) and a fixed count (i.e., rarefaction) of 300, but density metrics are based on the raw taxa list. Standardized metrics are indicated with an asterisk. NAMC OTU standardization uses the method of removing individuals identified to the coarser taxonomic resolution or merging finer level identifications to coarser levels.

See additional tables of benthic information in the appendices.

Electro-Fishing Studies

An electrofishing station was established in the project reaches by the Colorado Division of Wildlife (now Colorado Department of Parks & Wildlife, or CPW) in the mid 1980's. The site is not one of the agency's primary sampling sites, and is thus sampled infrequently at irregular intervals as the need to assess population dynamics and recreational harvest arises. In recent years, the site has been periodically sampled by the agency on average every two to five years. The station is located in

Happy Meadows Reach 22 (USFS lands) approximately ½ mile upstream of the Sportsmen's Paradise / USFS property boundary. The biotic monitoring sites map in the macroinvertebrates section of this document shows the location of the eletrofishing site, designated as South Platte River #5 by CPW fisheries personnel. The station is 440 feet long, and at base flow contains a wetted perimeter of approximately 32,885 ft2 (0.75 acres). The station is characterized by boulder and cobble riffle habitats with considerable in channel pocket water features. The downstream third of the station has been impacted by sediment accumulating due to the presence of the low head dam at the Sportsmen's Paradise / USFS property boundary.

The South Platte River #5 electrofishing site was most recently sampled by the CPW in the fall of 2004, 2006, & 2007. The sampling method used was a two pass depletion survey, utilizing a 5 anode array and shore mounted Smith-Root GPP pulse electrofisher and generator. The results of these surveys are shown in the table below.

SOUTH PLATTE RIVER #5 ELECTROFISHING STATION (HAPPY MEADOWS)						
Rainbow Trout and Brown Trout Combined						
Year	N	#/Mile	Biomass (lbs per acre)	Density (# per acre)	YOY Found	# > 14"
2004	71	855	33	95	38	3
2006	198	2361	87	261	118	10
2007	119	1420	66	157	40	4

The electrofishing data indicates that the Happy Meadows reach is functioning at less than it's potential, compared to other reaches in the South Platte River. Total biomass is less than robust in all of the sampling periods, and recruitment of young-of-the-year trout is relatively poor. Several factors may effect fish density and recruitment, including fishing pressure/harvest, and habitat degradation due to sediment from the Hayman fire scar and from Park County Road 112 adjacent to the river. A roads assessment of the road is expected to be undertaken in the next year, and will identify problem areas and propose treatments. Significant sediment sources from the Hayman burn scar have been treated as part of the overall Happy Meadows Sportsmen's Paradise Project. We anticipate that reduction in sediment inputs, coupled with the incorporation of substantial amounts of large wood for habitat formation and com-

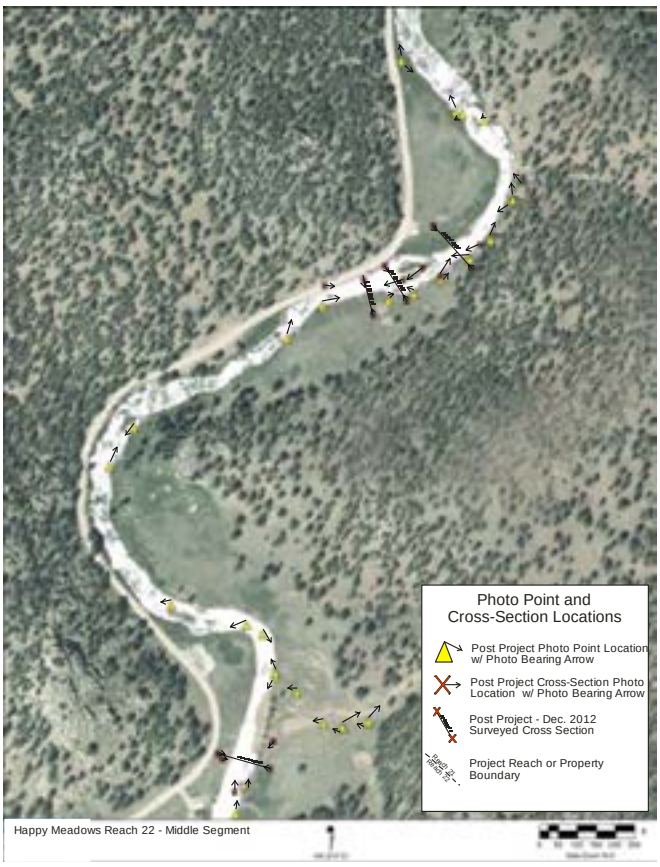
plexity, should result in improved trout recruitment and young-of-the-year survival in the project reaches. The earliest that the site will be re-sampled by the CPW will be in early November 2013.

Permanent Photo Points

One hundred and seventy permanent photo points have been established along the 4 mile project reaches along the South Platte River. Photo points include at least four photos of each project cross section, looking upstream and downstream and from each bank pin looking along the axis of the cross section. Additional photo points have been established where significant treatments, such as channel narrowing, riparian enhancement, and in-channel structure have been constructed. Photo points are a quick and easy monitoring technique that is especially useful in documenting changes in channel dimension and pattern, and riparian health. Several examples of changes already documented in the project reaches are shown below.

Photo points were established using a GPS enabled camera (Garmin 650t or Nikon 1 V2) to tag geospatial data to the image. Geospatial metadata for each image is listed in the tables below, and a maps showing the location and bearing of each photo are included in the maps that follow. Thumbnail images of each photo are included at the end of the document. High resolution copies of the images will be maintained in the project file for analytical purposes. We anticipate that photo point monitoring will continue each year in the fall, when stream flow conditions are similar to past photo assessments, and following the summer growing season so as to document changes in riparian condition.

The following seven maps display the photo point and cross-section locations.



Happy Meadows Reach 22 - Downstream Segment

Happy Meadows Reach 22 - Dam Site
Sportsmans Paradise Reach 21 - Upper Segment

Sportsmans Paradise Reach 21 - Downstream Segment
Sportsmans Paradise Reach 20 - Upstream Segment

Sportsmans Paradise Reach 20 - Middle Segment

Substrate Characterization and Analysis

Pre-project pebble count surveys were conducted by the USFS in 2006 & 2007, and can be found in CUSP's South Platte River Sportsmen's Paradise & Happy Meadows Reach 20, 21, & 22 River Assessment & Restoration Plan, 2011.

Stream Channel Stability Ratings & Bank Erosion Hazard Analysis (WARSSS)

We anticipate beginning the post project assessment of channel stability and bank erosion hazard in 2014, following a high flow cycle and at least one growing season for freshly planted willow and recently installed sedge mats.

Riparian Vegetation & Disturbed Areas

Areas disturbed by construction activities were treated by volunteers immediately following construction work in 2011 and 2012. Photo points have been established in these areas, and will be monitored following at least one growing season to assess effectiveness.

POST-PROJECT MONITORING

Post-project monitoring commenced two months following completion of project construction. Monitoring and evaluation of the project will follow the Sampling and Analysis Plan: Upper South Platte Nonpoint Source Initiative, 2011, developed by the Coalition for the Upper South Platte and the US Forest Service. Post project monitoring activities completed in 2012 include establishment of photo-point monitoring sites and post project cross-section analysis of a sub-set of thirteen cross-sections in the project reaches. The results of these surveys are included in this report.

Post project monitoring activities will continue over the next several years to evaluate the success of the project. At this point, we expect to conduct a complete channel morphology study within three years of project completion. This data will be

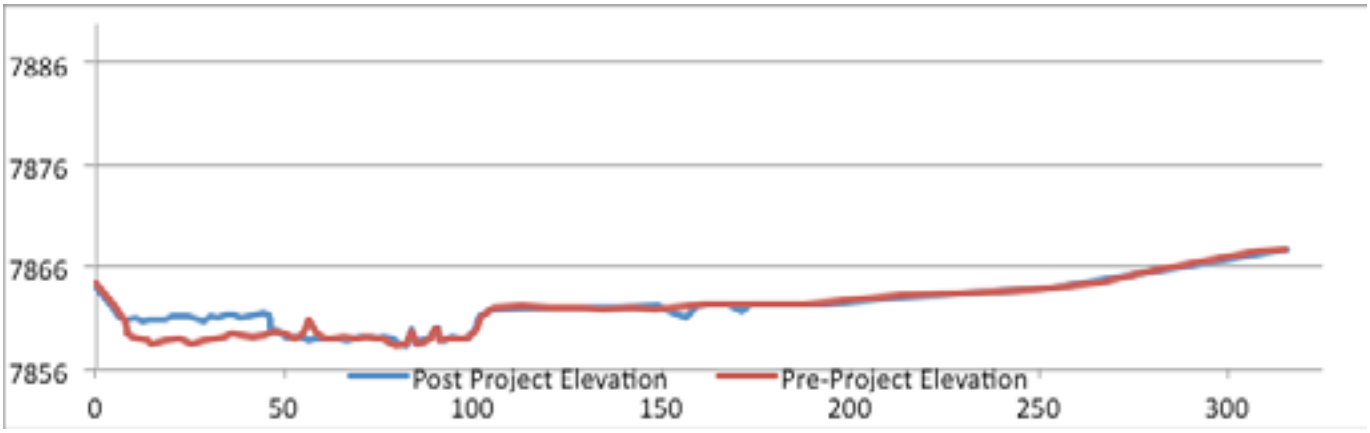
utilized to complete a post-project HEC-RAS model and WARSSS assessment for the project reaches. Additional biotic surveys will be repeated by CPW & USFS personnel in the next two years.

Cross Section Analysis

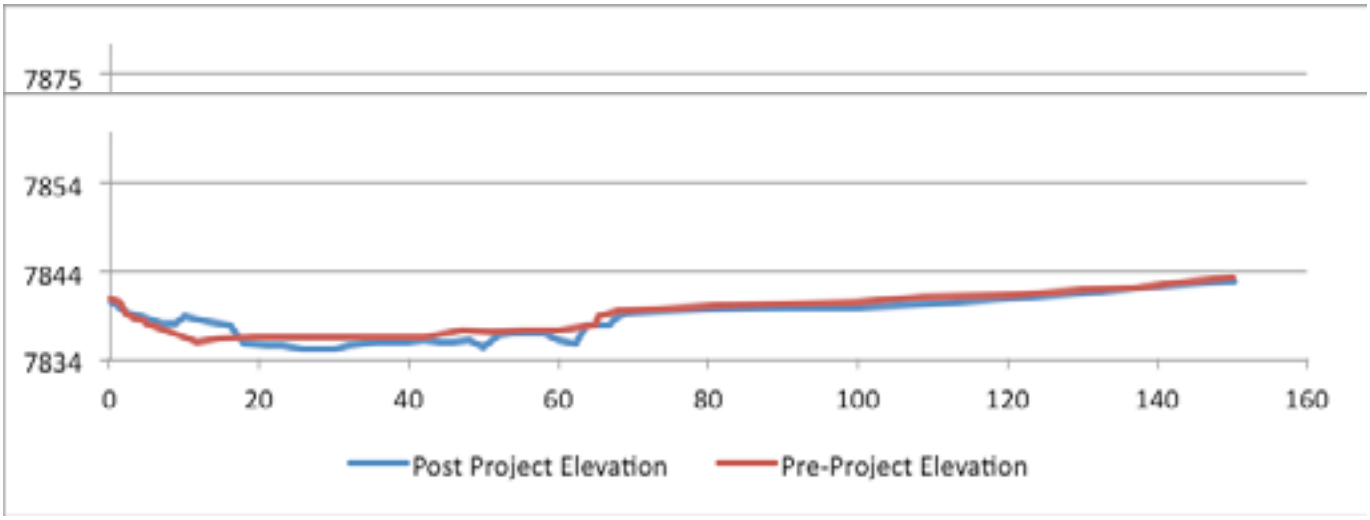
A sub-set of thirteen representative cross sections were identified following construction to assess changes in channel dimension and profile in the project reaches. The location of these cross-sections is shown on the map on the following page. The table below outlines pre-project conditions and post project changes in several critical channel attributes, including bank-full channel width, mean depth (DMEAN), maximum channel depth (DMAX), and width to depth ratio. Plots of each cross-section are provided on the following pages.

		BF Width		Mean Depth		Max Depth		W/D Ratio	
CROSS SECTION #	HABITAT	PRE-PROJECT	POST PROJECT	PRE-PROJECT	POST PROJECT	PRE-PROJECT	POST PROJECT	PRE-PROJECT	POST PROJECT
HM XS#690	RIFFLE	94.6	56.3	1.54	1.95		3.04	61.3	28.9
HM XS#687	RIFFLE	81.2	63.6	1.76	2.35	2.63	4.53	46.1	27.0
HM XS#680	RIFFLE	61	54.6	1.61	2.46	2.62	3.61	38.0	22.2
HM XS#679	RIFFLE	118	75.9	1.26	1.64	2.14	2.21	93.5	46.2
HM XS#678	RIFFLE	60.3	62.7	2.20	2.28	3.79	4.54	27.5	27.5
HM XS#669	RIFFLE	123.8	67.1	1.56	1.56	2.40	2.19	79.2	43.0
HM XS#668	RIFFLE	126.3	46.2	1.66	1.98	3.01	2.62	76.1	23.4
HM XS#667	RIFFLE	103.3	50.5	1.81	2.28	3.47	3.51	57.2	22.2
DAM Site #8	RIFFLE	99	37.3	0.78	2.20	2.42	3.17	127.5	17.0
DAM Site #4	POOL	226	44.7	1.74	3.27	3.77	5.52	129.9	13.7
DAM Site #2	RIFFLE	84	54.4	0.94	1.27	1.49	2.44	89.4	42.7
SP XS#112	POOL	66.9	63.3	2.26	2.57	4.49	4.66	29.5	24.6
SP XS#111	RIFFLE	95.4	74	1.57	2.06	2.45	2.97	60.9	35.9

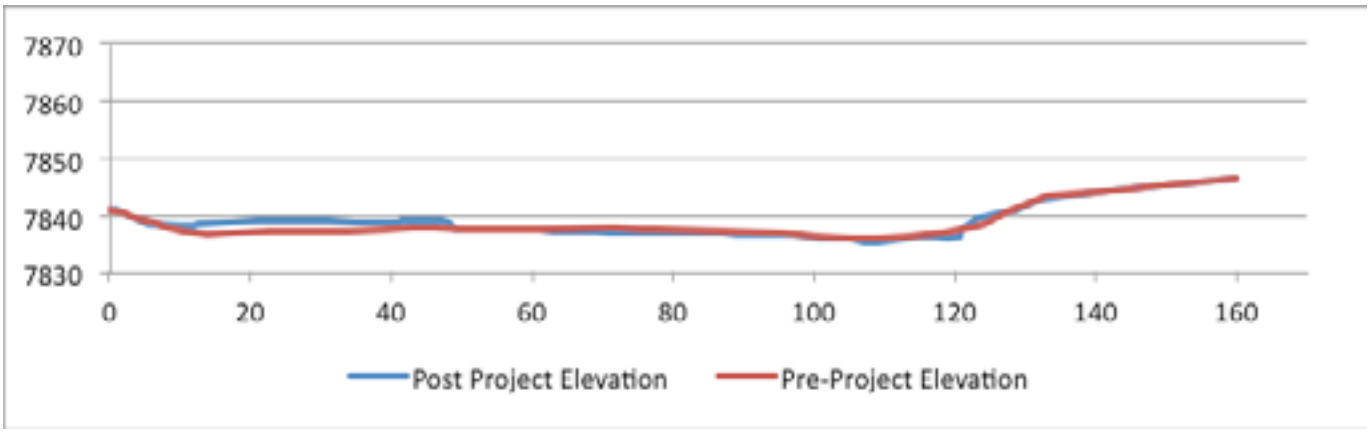
Width to depth ratios in the subset sample have been significantly reduced as a result of construction of new bank-full riparian benches and closure of multiple threaded channels. Post project W/D ratios in riffle habitats now average 30.5, down from a pre project average of over 68. DMEAN shows an increase in the riffle habitats, and DMEAN has increased in the pool habitats. While the results of the 2012 cross-section surveys are promising, we will wait until surveys are complete following an extended high flow period to assess the success of these efforts.



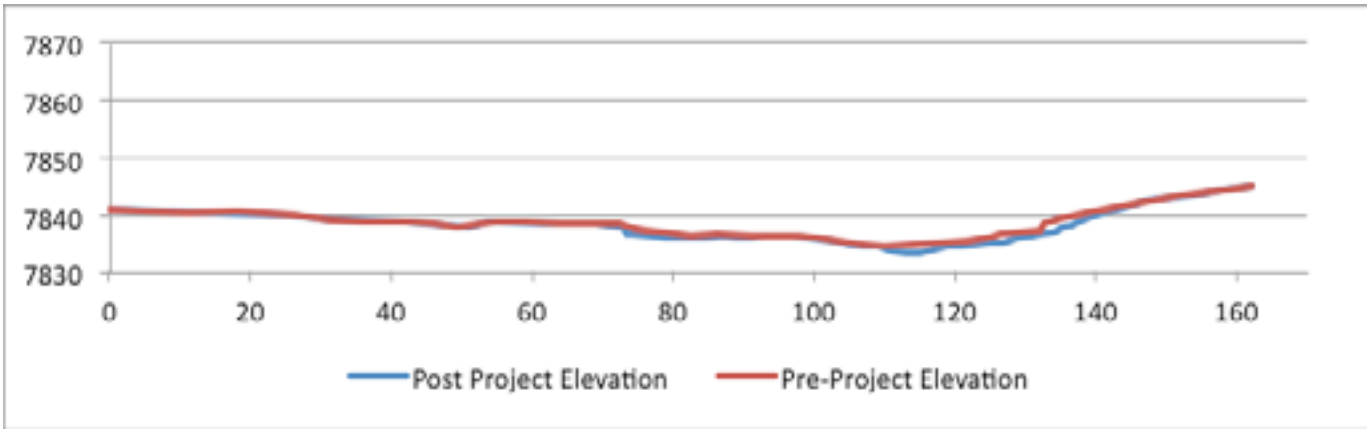
Happy Meadows Cross Section #690 – New riparian bank full bench on left bank.



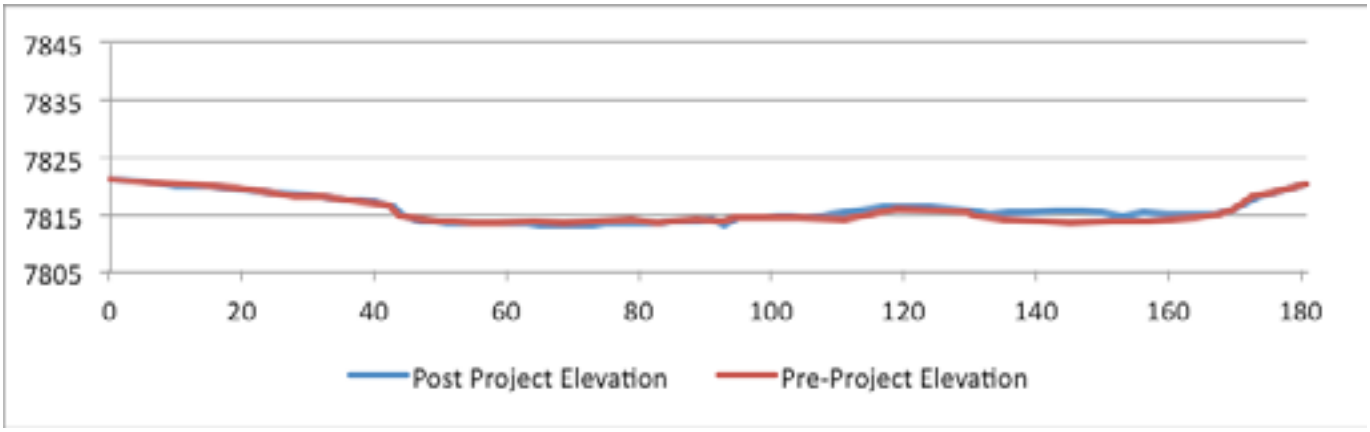
Happy Meadows Cross Section #687 – New riparian bank full bench on right bank



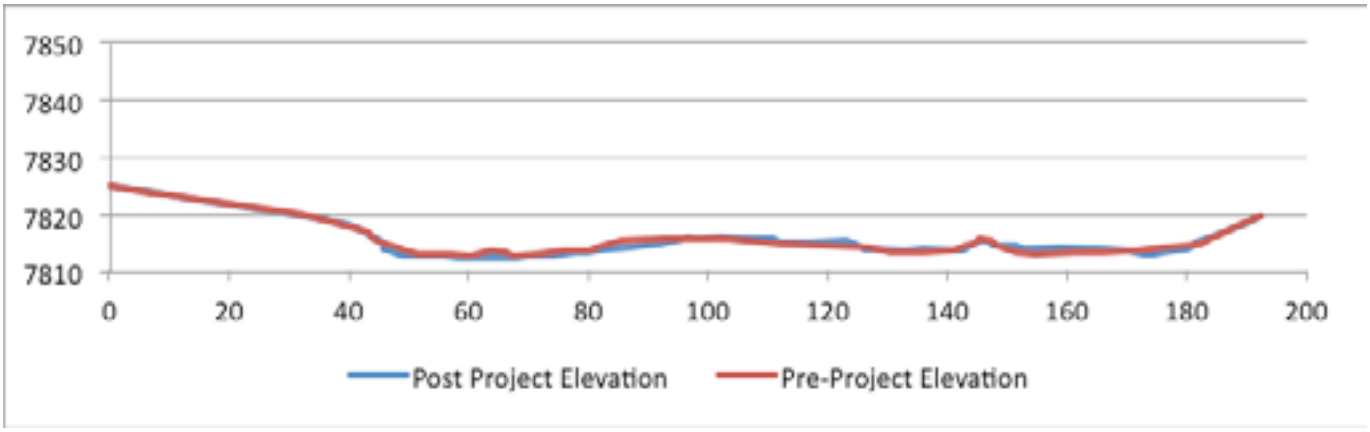
Happy Meadows Cross Section #680 – Small riparian bank full bench along road/river interface.



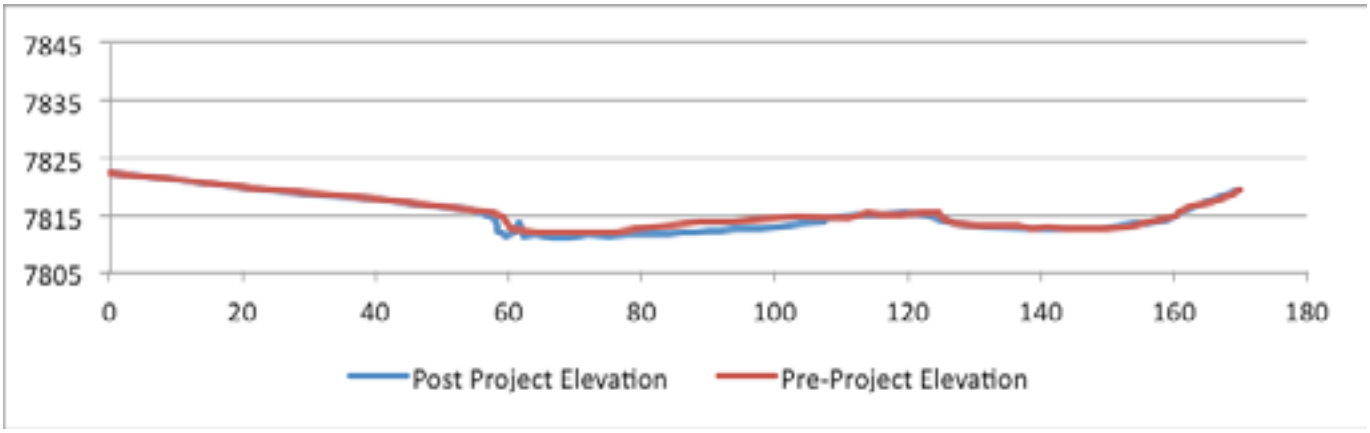
Happy Meadows Cross Section #679 – New riparian bench and side channel closure to reduce channel width/depth ratio in an over-wide glide habitat.



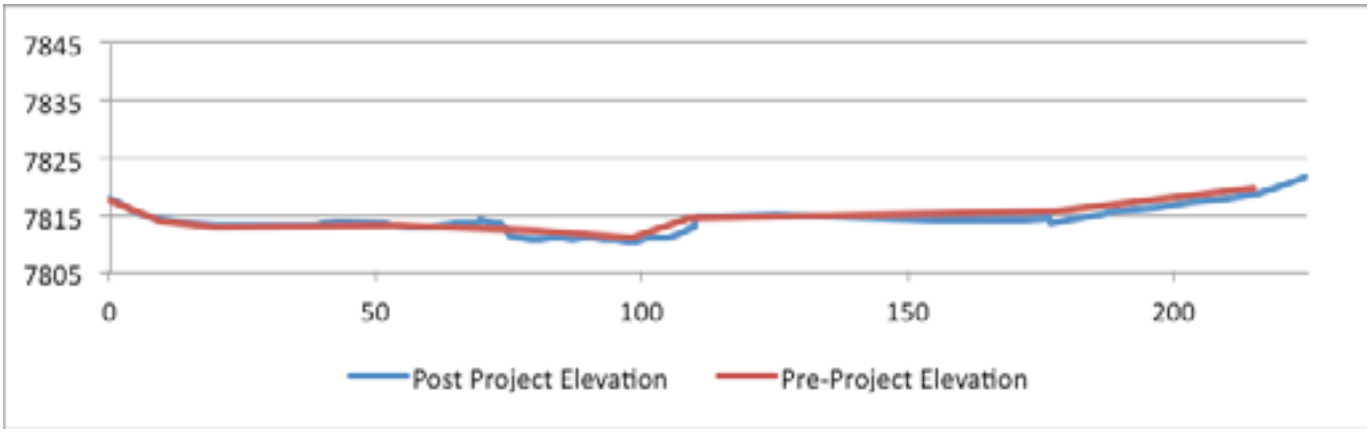
Happy Meadows Cross Section #678 – Small riparian bench and deepening of lateral scour pool.



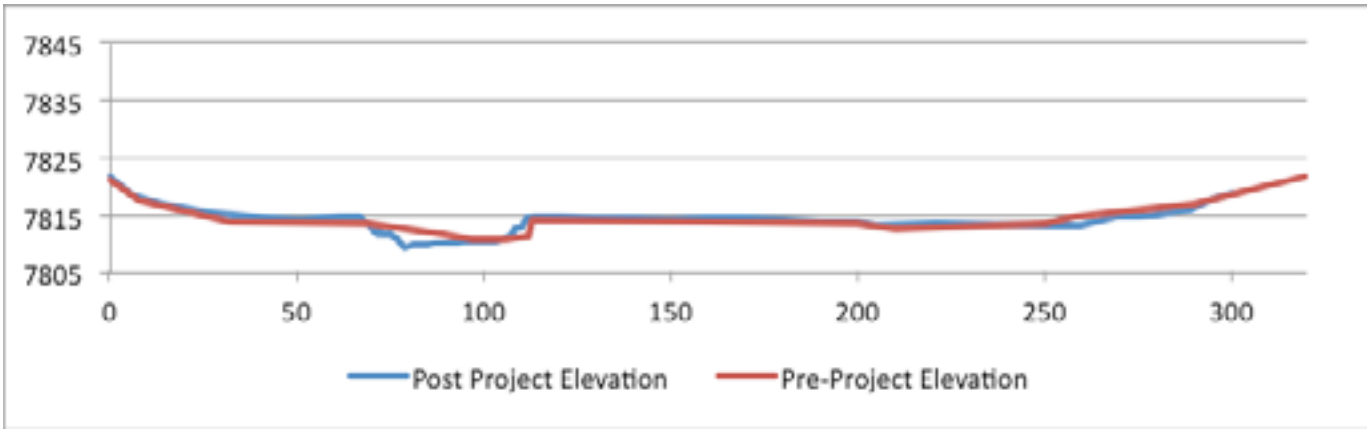
Happy Meadows Cross Section #669 – Closed 2nd channel on right.



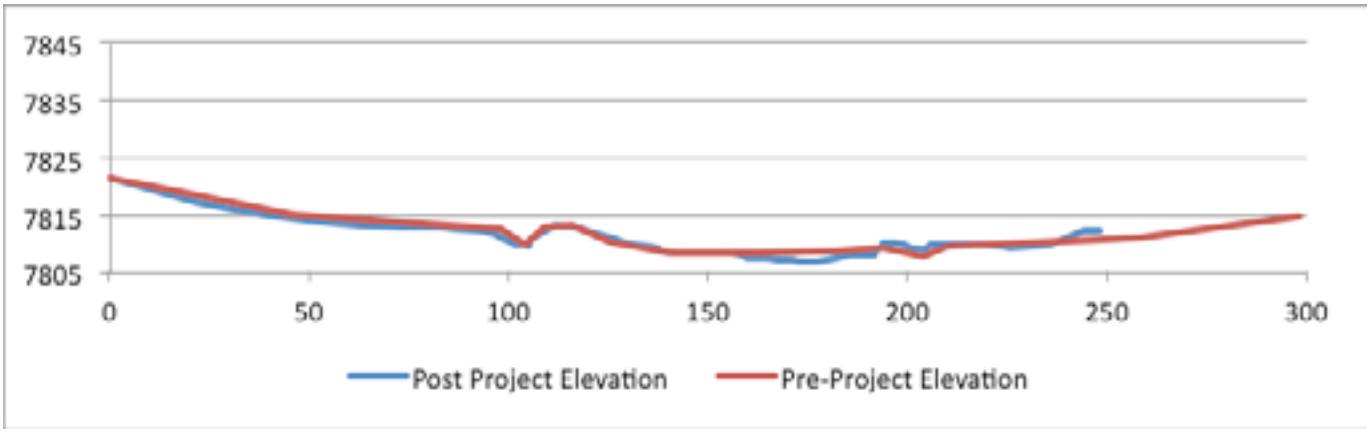
Happy Meadows Cross Section #668 – Closed 2nd channel on right, and increased cross-sectional area of left channel to maintain bank full capacity in a single thread channel.



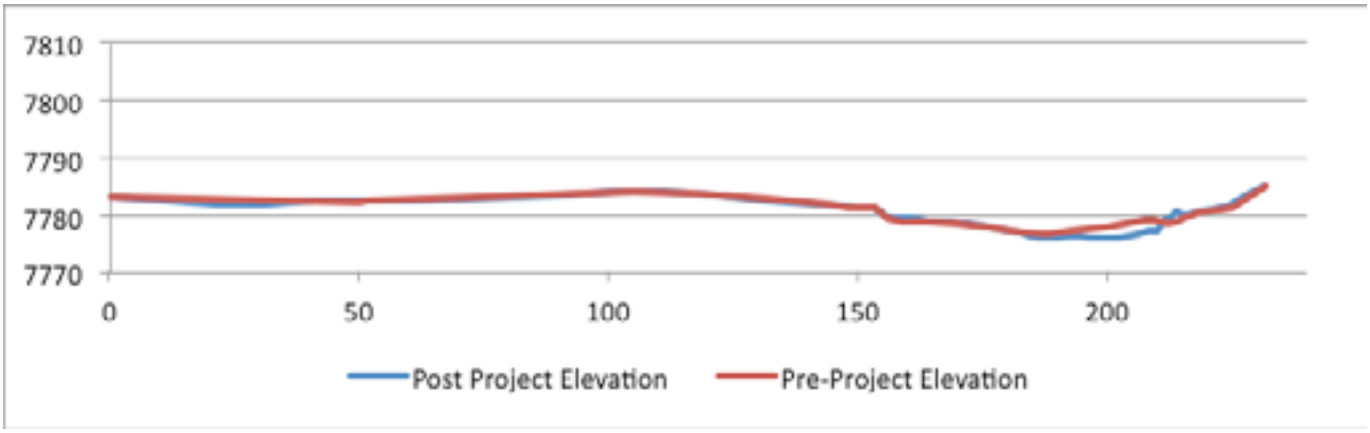
Happy Meadows Cross Section #667 – Closed 2nd channel on right and converted to backwater pool habitat for YOY at high flow. Increased cross sectional area of the left channel to maintain bank full capacity of the new single thread channel.



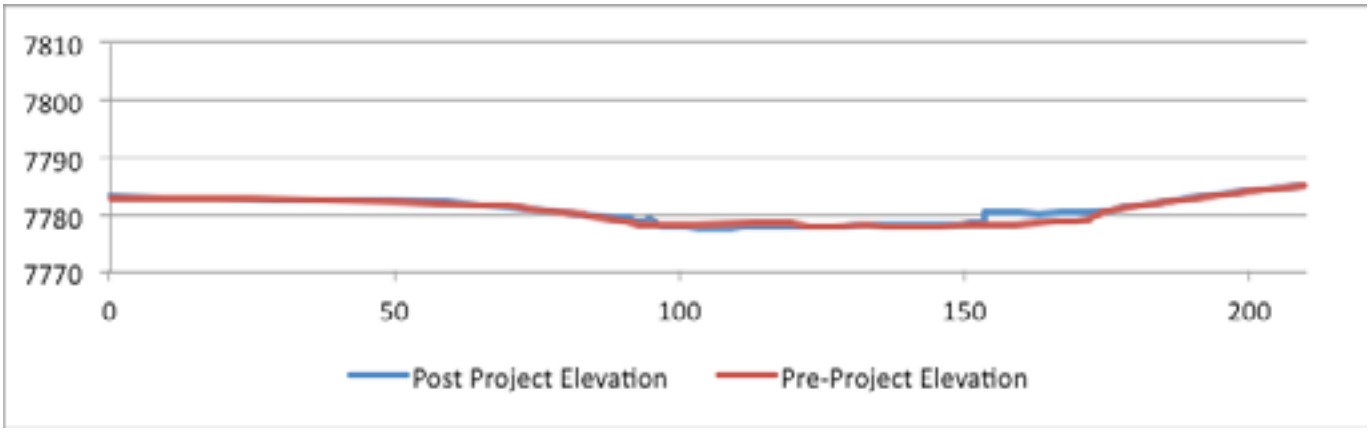
Sportsmen's Paradise Dam Site Cross Section #8 – Defined a narrow channel in the mud flat upstream of the old dam site.



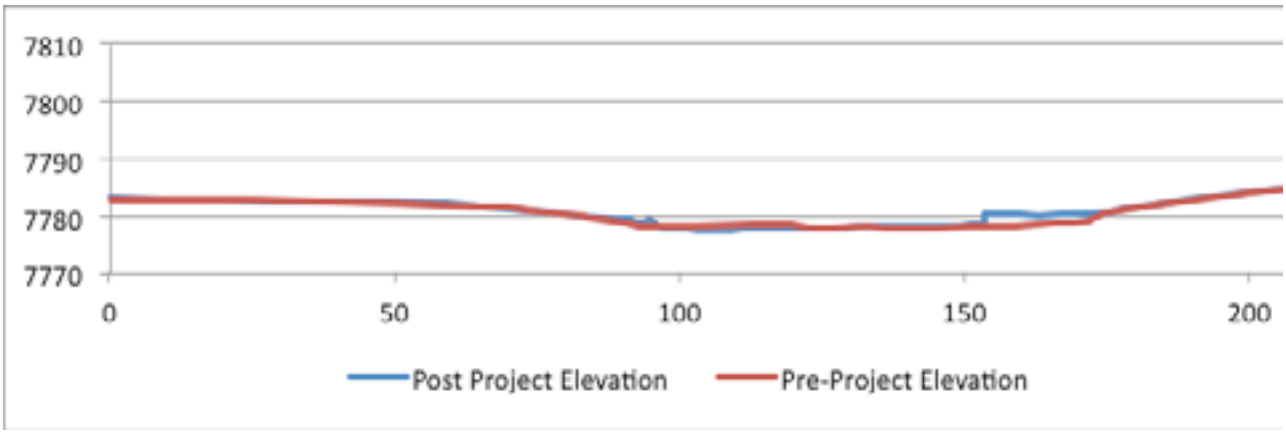
Sportsmen's Paradise Dam Site Cross Section #4 – Immediately upstream of the old dam site. Defined a narrow channel in the mud flat and stepped the bed elevation down to match the lower channel elevation.



Sportsmen's Paradise Dam Site Cross Section #2 – Immediately downstream of the old dam site. New riparian bank-full bench on the right side of the channel, and a new channel and confluence for Vermillion Creek.



Sportsmen's Paradise Cross Section #112 – Narrowed and deepened the channel through a lateral scour pool near the downstream boundary of Reach 20.



Sportsmen's Paradise Cross Section #111 – New riparian bank full bench on right side of the river to reduce width/depth ratio in a severely over-wide cobble/boulder riffle near the downstream boundary of Reach 20.

FUTURE EFFORTS

There will be additional monitoring over the next several years. For example, benthic organisms, fish shocking, photo points, and cross-sections will be rechecked within the next three years. A post project longitudinal channel profile has not yet been completed in the project reaches. We anticipate that this survey will also be undertaken within the larger post project monitoring effort within three years following completion of construction. Pre-project longitudinal profile surveys can be found in CUSP's South Platte River Sportsmen's Paradise & Happy Meadows Reach 20, 21, & 22 River Assessment & Restoration Plan, 2011.

Substrate Characterization and Analysis

Pre-project pebble count surveys were conducted by the USFS in 2006 & 2007, and can be found in CUSP's South Platte River Sportsmen's Paradise & Happy Meadows Reach 20, 21, & 22 River Assessment & Restoration Plan, 2011. Post project substrate sampling will be completed in the project reaches following at least one bank full high flow period. We anticipate that this survey will be undertaken within the larger post project monitoring effort three years following completion of construction.

Stream Channel Stability Ratings & Bank Erosion Hazard Analysis (WARSSS)

We anticipate beginning the post project assessment of channel stability and bank erosion hazard in 2014, following a high flow cycle and at least one growing season for freshly planted willow and recently installed sedge mats.

Riparian Vegetation & Disturbed Areas

Areas disturbed by construction activities were treated by volunteers immediately following construction work in 2011 and 2012. Photo points have been established in these areas, and will be monitored following at least one growing season to assess effectiveness.

Additional

Habitat mapping survey and a channel morphology surveys may be repeated five to ten years following completion of the project.

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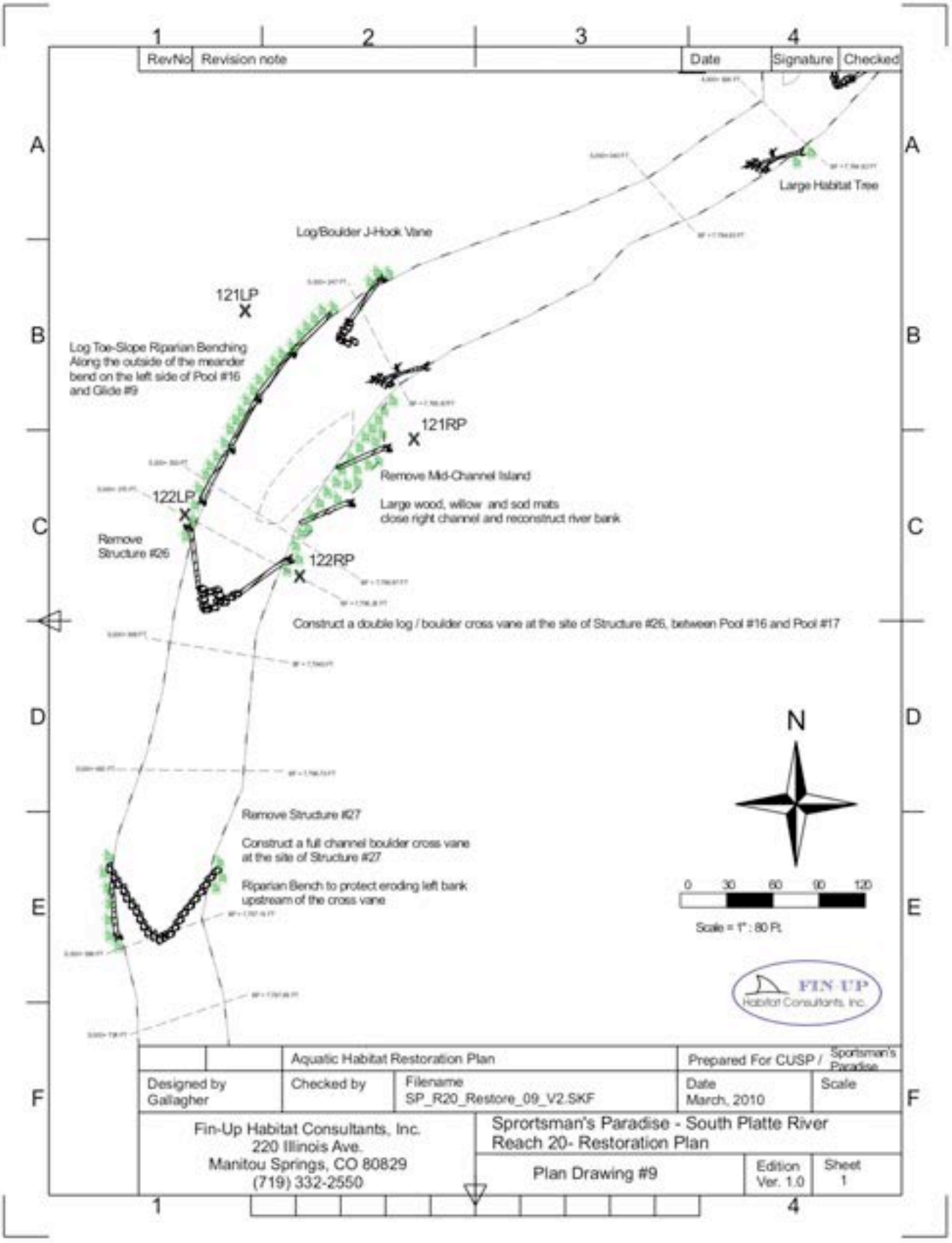
Ariel Photography provided by the US Forest Service. Topographical maps created using USGS and Delorme TOPO 8.0

APPENDIX A

AS-BUILT DRAWINGS

The following pages provide as-built drawings of the project. This documentation is critical to future project monitoring and evaluation, and to our ability to understand and adapt to changes as more projects are implemented in the watershed in years to come.


RevNo
Revision note
Date
Signature
Checked
Large Habitat Tree
Log/Boulder J-Hook Vane
121LP
Log Toe-Slope Riparian Benching
Along the outside of the meander
bend on the left side of Pool #16
and Glide #9
121RP
Remove Mid-Channel Island
Large wood, willow and sod mats
close right channel and reconstruct river bank
122LP
Remove
Structure #26
122RP
Construct a double log / boulder cross vane at the site of Structure #26, between Pool #16 and Pool #17
Remove Structure #27
Construct a full channel boulder cross vane
at the site of Structure #27
Riparian Bench to protect eroding left bank
upstream of the cross vane
N
0
30
60
90
120
Scale = 1" : 80 Ft
FIN UP
Habitat Consultants, Inc.
Aquatic Habitat Restoration Plan
Prepared For CUSP / Sportsman's Paradise
Designed by
Gallagher
Checked by
Filename
SP_R20_Restore_09_V2.SKF
Date
March, 2010
Scale
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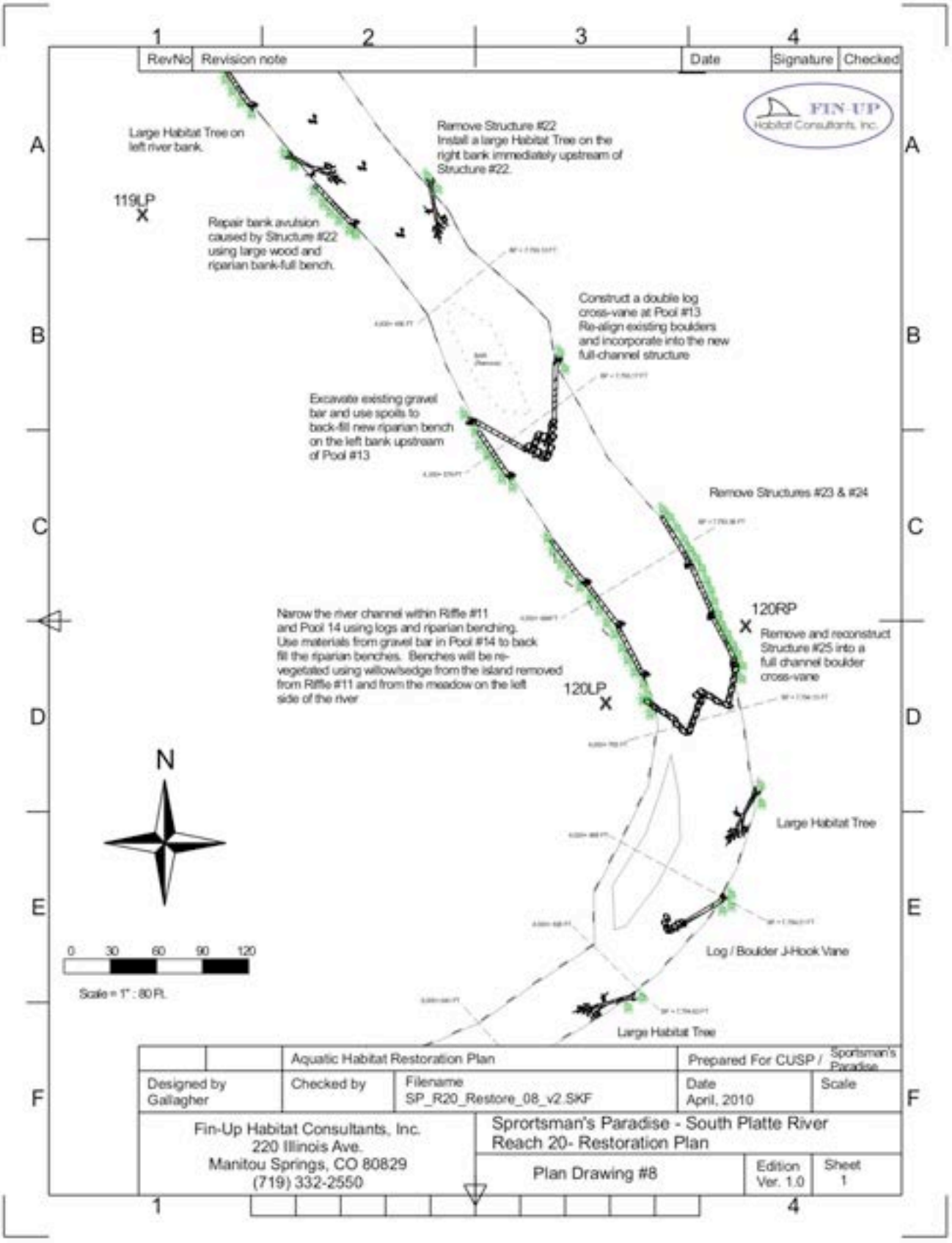
Plan Drawing #9
Edition
Ver. 1.0
Sheet
1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RevNo
Revision note
Date
Signature
Checked
FIN-UP
Habitat Consultants, Inc.
A
B
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F
Large Habitat Tree on left river bank.
119LP
Repair bank avulsion caused by Structure #22 using large wood and riparian bank-full bench.
Remove Structure #22
Install a large Habitat Tree on the right bank immediately upstream of Structure #22.
Construct a double log cross-vane at Pool #13
Re-align existing boulders and incorporate into the new full-channel structure
Excavate existing gravel bar and use spoils to back-fill new riparian bench on the left bank upstream of Pool #13
Remove Structures #23 & #24
120RP
Remove and reconstruct Structure #25 into a full channel boulder cross-vane
Narow the river channel within Riffle #11 and Pool 14 using logs and riparian benching. Use materials from gravel bar in Pool #14 to back fill the riparian benches. Benches will be re-vegetated using willow/sedge from the island removed from Riffle #11 and from the meadow on the left side of the river
120LP
N
0
30
60
90
120
Scale = 1" : 80 Ft.
Large Habitat Tree
Log / Boulder J-Hook Vane
Large Habitat Tree
Aquatic Habitat Restoration Plan
Prepared For CUSP / Sportsman's Paradise
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Filename SP_R20_Restore_08_v2.SKF
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Scale
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Plan Drawing #8
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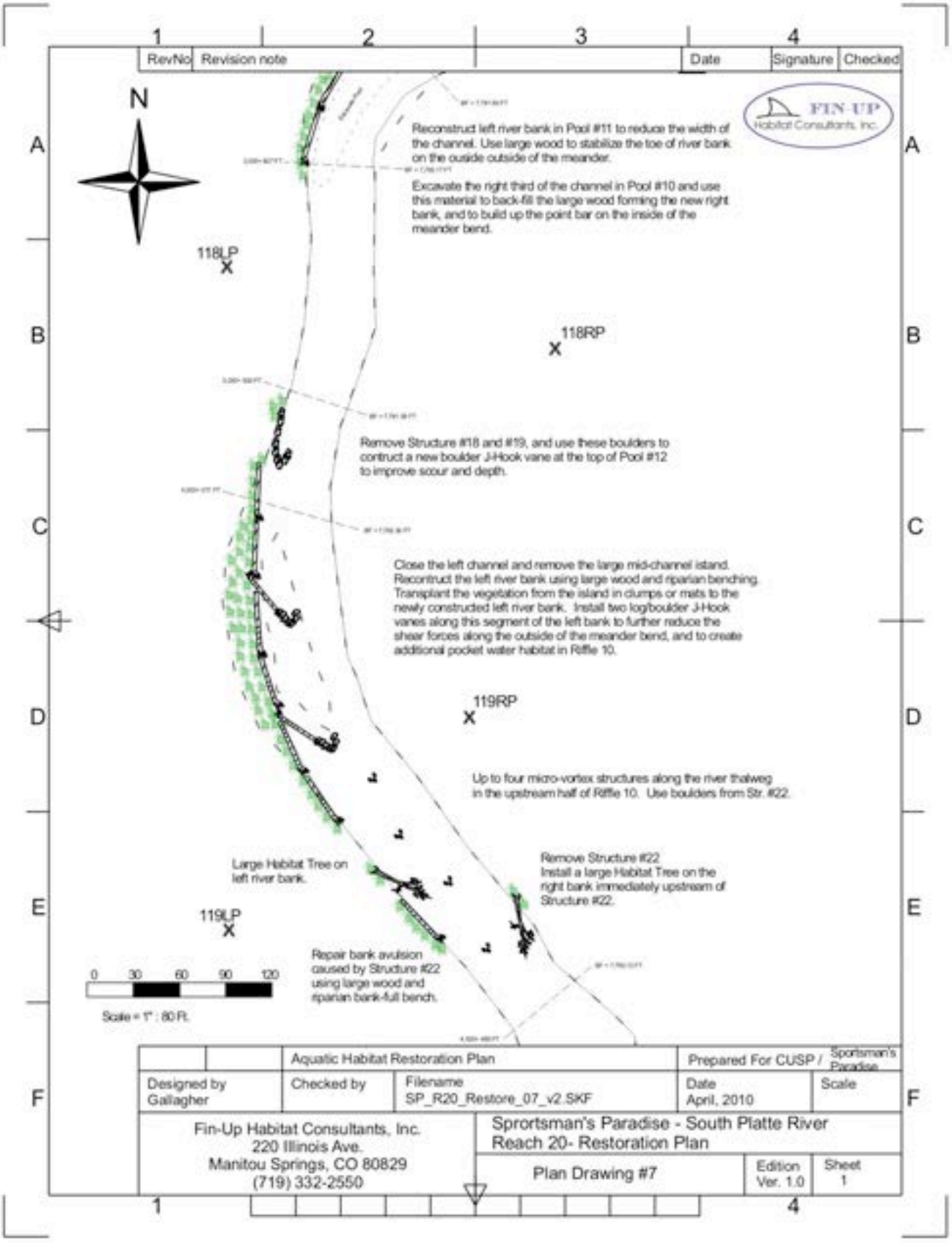
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Signature
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FIN-UP
Habitat Consultants, Inc.
N
Reconstruct left river bank in Pool #11 to reduce the width of the channel. Use large wood to stabilize the toe of river bank on the ouside outside of the meander.
Excavate the right third of the channel in Pool #10 and use this material to back-fill the large wood forming the new right bank, and to build up the point bar on the inside of the meander bend.
118LP
118RP
Remove Structure #18 and #19, and use these boulders to contruct a new boulder J-Hook vane at the top of Pool #12 to improve scour and depth.
Close the left channel and remove the large mid-channel island. Recontruct the left river bank using large wood and riparian benching. Transplant the vegetation from the island in clumps or mats to the newly constructed left river bank. Install two log/boulder J-Hook vanes along this segment of the left bank to further reduce the shear forces along the outside of the meander bend, and to create additional pocket water habitat in Riffle 10.
119RP
Up to four micro-vortex structures along the river thalweg in the upstream half of Riffle 10. Use boulders from Str. #22.
Large Habitat Tree on left river bank.
Remove Structure #22
Install a large Habitat Tree on the right bank immediately upstream of Structure #22.
119LP
Repair bank avulsion caused by Structure #22 using large wood and riparian bank-full bench.
0 30 60 90 120
Scale = 1" : 80 Ft.
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Prepared For CUSP / Sportsman's Paradise
Designed by Gallagher
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Filename SP_R20_Restore_07_v2.SKF
Date April, 2010
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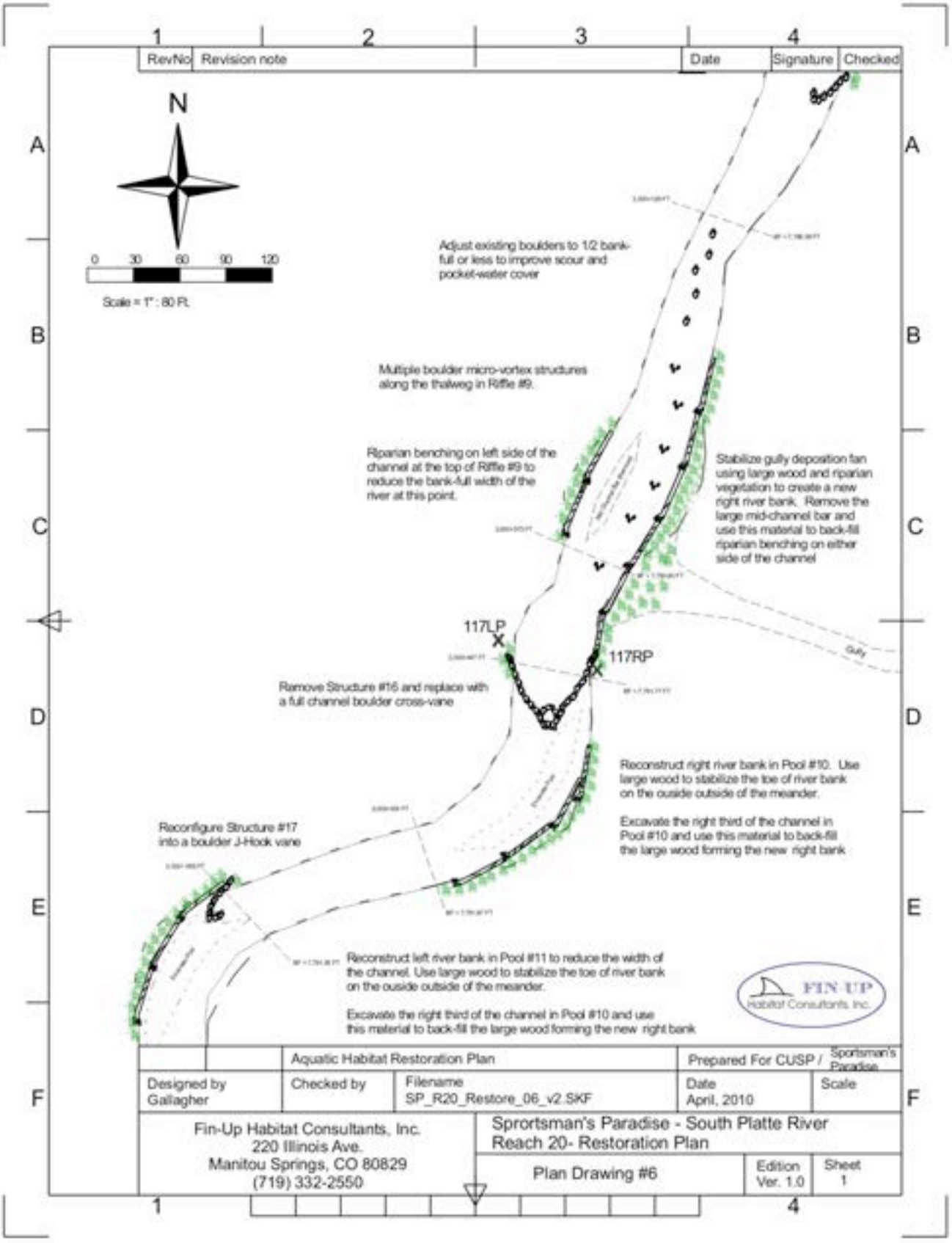
RevNo
Revision note
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Signature
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N
0 30 60 90 120
Scale = 1" : 80 Ft.
Adjust existing boulders to 1/2 bank-full or less to improve scour and pocket-water cover
Multiple boulder micro-vortex structures along the thalweg in Riffle #9.
Riparian benching on left side of the channel at the top of Riffle #9 to reduce the bank-full width of the river at this point.
Stabilize gully deposition fan using large wood and riparian vegetation to create a new right river bank. Remove the large mid-channel bar and use this material to back-fill riparian benching on either side of the channel
117LP
117RP
Gully
Remove Structure #16 and replace with a full channel boulder cross-vane
Reconstruct right river bank in Pool #10. Use large wood to stabilize the toe of river bank on the ouside outside of the meander.
Excavate the right third of the channel in Pool #10 and use this material to back-fill the large wood forming the new right bank
Reconfigure Structure #17 into a boulder J-Hook vane
Reconstruct left river bank in Pool #11 to reduce the width of the channel. Use large wood to stabilize the toe of river bank on the ouside outside of the meander.
Excavate the right third of the channel in Pool #10 and use this material to back-fill the large wood forming the new right bank
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Designed by Gallagher
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Filename SP_R20_Restore_06_v2.SKF
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Plan Drawing #6
Edition Ver. 1.0
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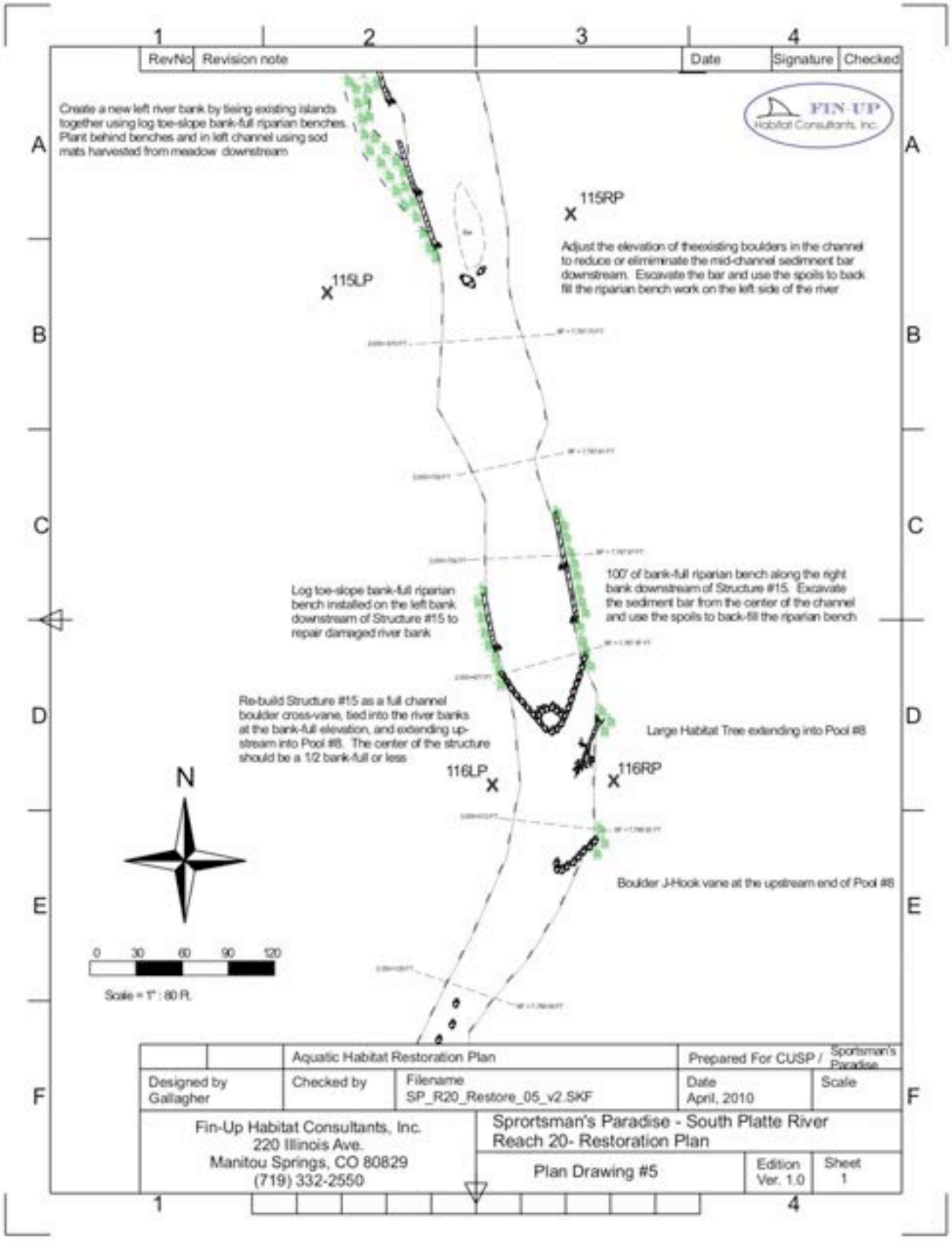
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Revision note
Date
Signature
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FIN-UP
Habitat Consultants, Inc.
Create a new left river bank by tieing existing islands together using log toe-slope bank-full riparian benches. Plant behind benches and in left channel using sod mats harvested from meadow downstream
115RP
115LP
Adjust the elevation of theexisting boulders in the channel to reduce or elimininate the mid-channel sedimnent bar downstream. Escavate the bar and use the spoils to back fill the riparian bench work on the left side of the river
Log toe-slope bank-full riparian bench installed on the left bank downstream of Structure #15 to repair damaged river bank
100' of bank-full riparian bench along the right bank downstream of Structure #15. Excavate the sediment bar from the center of the channel and use the spoils to back-fill the riparian bench
Re-build Structure #15 as a full channel boulder cross-vane, tied into the river banks at the bank-full elevation, and extending up-stream into Pool #8. The center of the structure should be a 1/2 bank-full or less
Large Habitat Tree extending into Pool #8
116LP
116RP
Boulder J-Hook vane at the upstream end of Pool #8
N
0 30 60 90 120
Scale = 1" : 60 Ft.
Aquatic Habitat Restoration Plan
Prepared For CUSP / Sportsman's Paradise
Designed by Gallagher
Checked by
Filename SP_R20_Restore_05_v2.SKF
Date April, 2010
Scale
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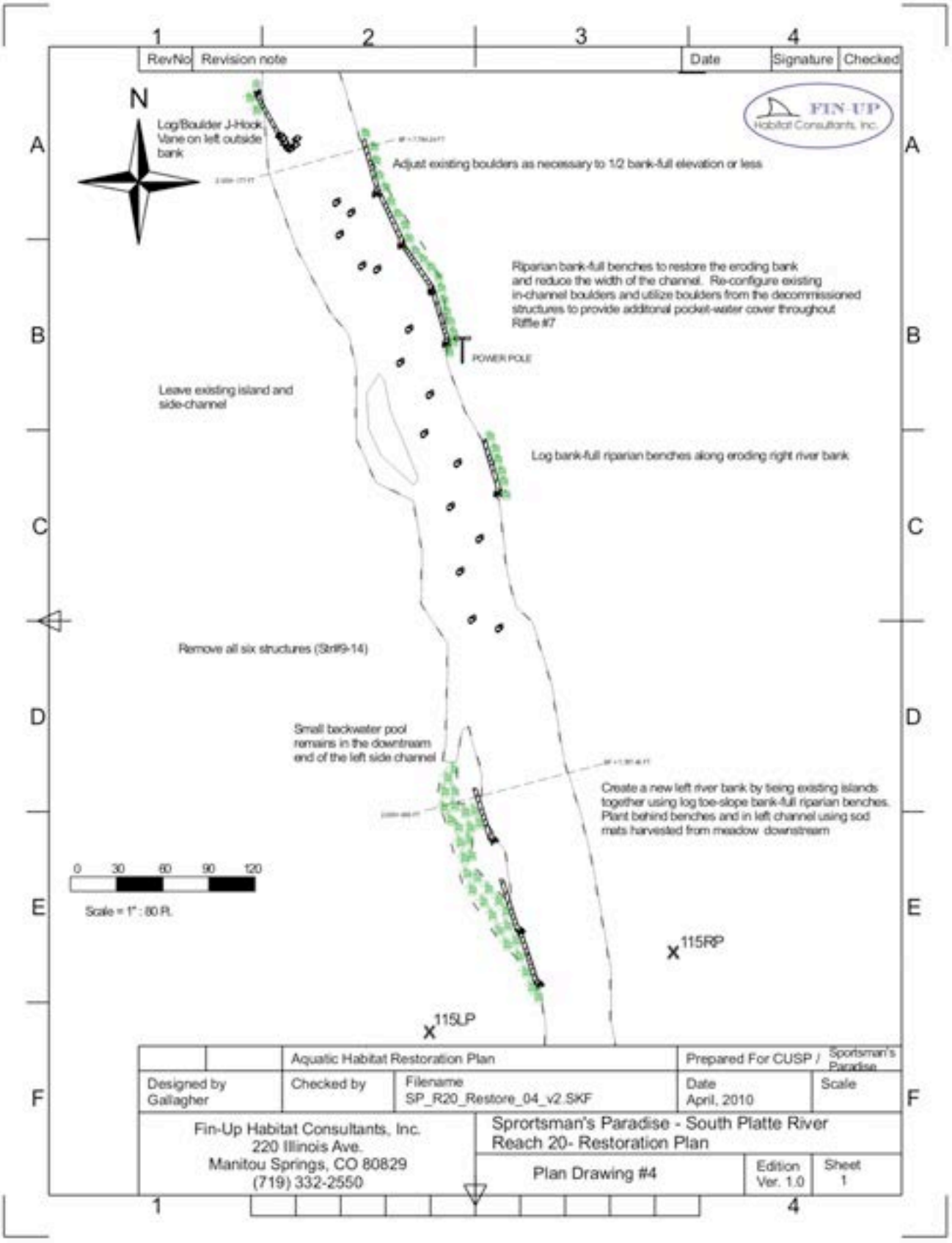
Plan Drawing #5
Edition Ver. 1.0
Sheet 1


RevNo
Revision note
Date
Signature
Checked
N
FIN-UP
Habitat Consultants, Inc.
Log/Boulder J-Hook Vane on left outside bank
Adjust existing boulders as necessary to 1/2 bank-full elevation or less
Riparian bank-full benches to restore the eroding bank and reduce the width of the channel. Re-configure existing in-channel boulders and utilize boulders from the decommissioned structures to provide additional pocket-water cover throughout Riffle #7
POWER POLE
Leave existing island and side-channel
Log bank-full riparian benches along eroding right river bank
Remove all six structures (Str#9-14)
Small backwater pool remains in the downtream end of the left side channel
Create a new left river bank by tieing existing islands together using log toe-slope bank-full riparian benches. Plant behind benches and in left channel using sod mats harvested from meadow downstream
0 30 60 90 120
Scale = 1" : 80 ft.
115RP
115LP
Aquatic Habitat Restoration Plan
Prepared For CUSP / Sportsman's Paradise
Designed by Gallagher
Checked by
Filename SP_R20_Restore_04_v2.SKF
Date April, 2010
Scale
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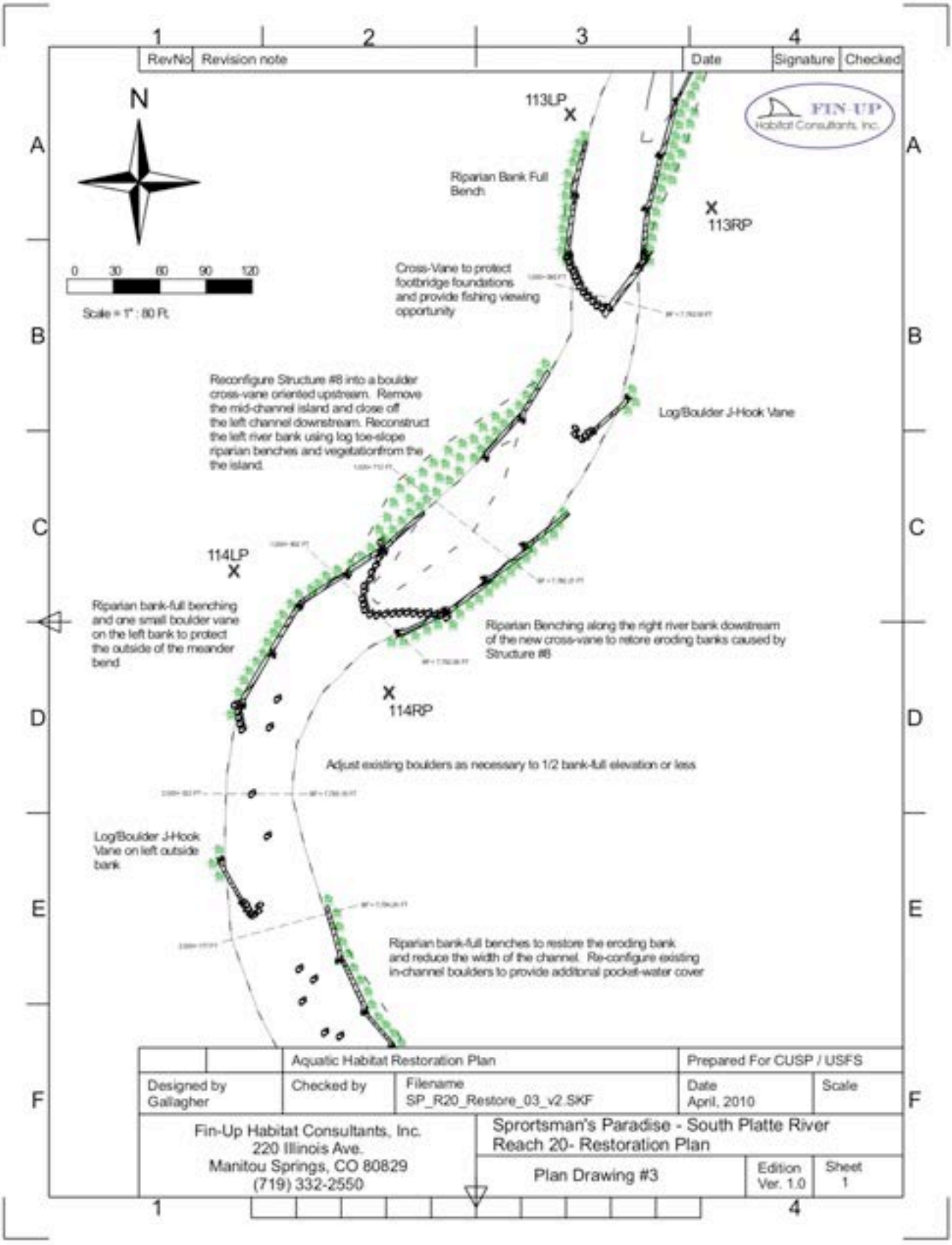
Reach 20- Restoration Plan
Plan Drawing #4
Edition Ver. 1.0
Sheet 1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Revision note
Date
Signature
Checked
N
0 30 60 90 120
Scale = 1" : 80 Ft.
113LP
113RP
Riparian Bank Full Bench
Cross-Vane to protect footbridge foundations and provide fishing viewing opportunity
Reconfigure Structure #8 into a boulder cross-vane oriented upstream. Remove the mid-channel island and close off the left channel downstream. Reconstruct the left river bank using log toe-slope riparian benches and vegetationfrom the the island.
Log/Boulder J-Hook Vane
114LP
Riparian bank-full benching and one small boulder vane on the left bank to protect the outside of the meander bend
Riparian Benching along the right river bank downstream of the new cross-vane to retore eroding banks caused by Structure #8
114RP
Adjust existing boulders as necessary to 1/2 bank-full elevation or less
Log/Boulder J-Hook Vane on left outside bank
Riparian bank-full benches to restore the eroding bank and reduce the width of the channel. Re-configure existing in-channel boulders to provide additional pocket-water cover
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Aquatic Habitat Restoration Plan
Prepared For CUSP / USFS
Designed by Gallagher
Checked by
Filename SP_R20_Restore_03_v2.SKF
Date April, 2010
Scale
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Reach 20- Restoration Plan
Plan Drawing #3
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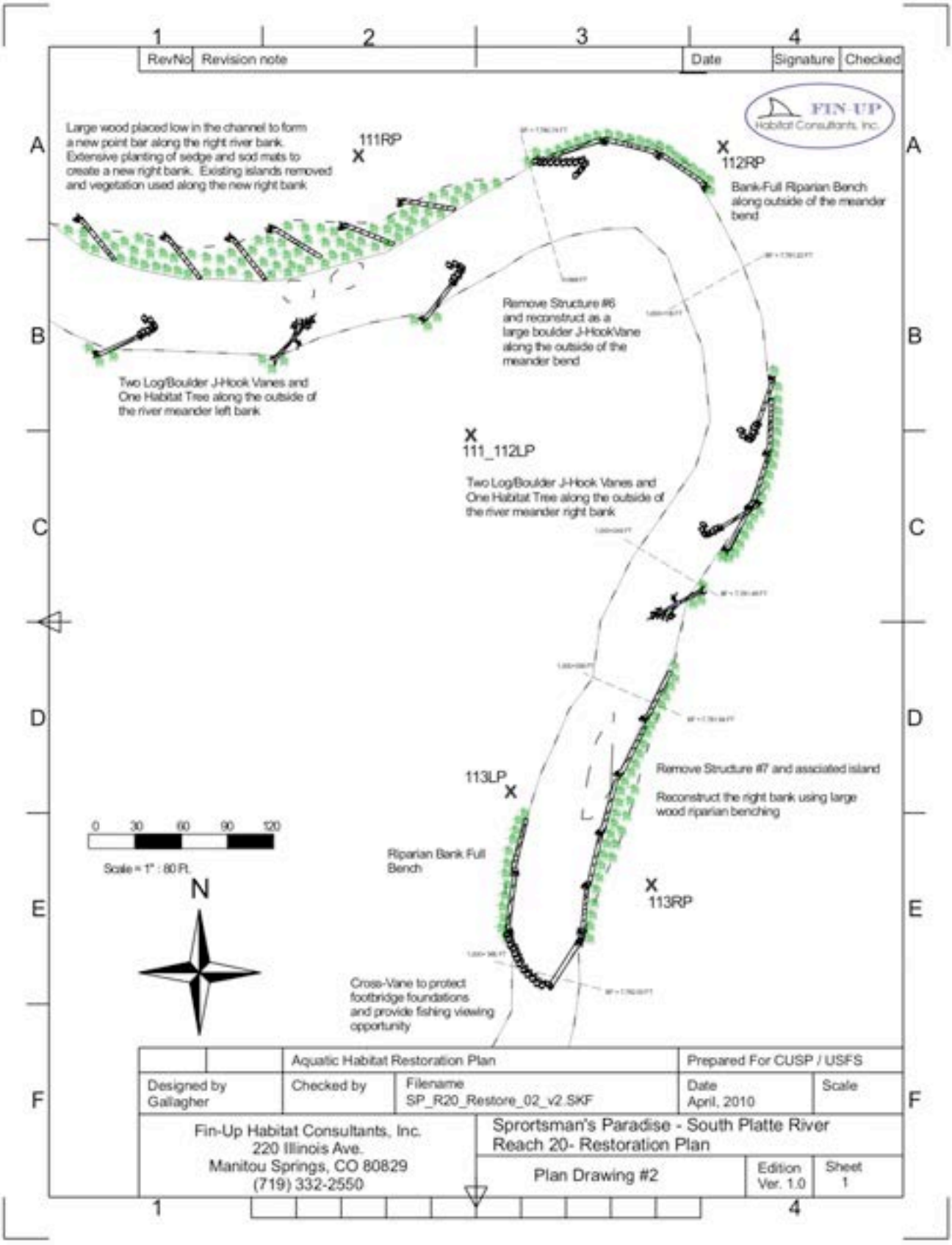
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Date
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FIN-UP
Habitat Consultants, Inc.
Large wood placed low in the channel to form a new point bar along the right river bank. Extensive planting of sedge and sod mats to create a new right bank. Existing islands removed and vegetation used along the new right bank
111RP
112RP
Bank-Full Riparian Bench along outside of the meander bend
Remove Structure #6 and reconstruct as a large boulder J-Hook/Vane along the outside of the meander bend
Two Log/Boulder J-Hook Vanes and One Habitat Tree along the outside of the river meander left bank
111_112LP
Two Log/Boulder J-Hook Vanes and One Habitat Tree along the outside of the river meander right bank
113LP
Remove Structure #7 and associated island
Reconstruct the right bank using large wood riparian benching
Riparian Bank Full Bench
113RP
Cross-Vane to protect footbridge foundations and provide fishing viewing opportunity
0 30 60 90 120
Scale = 1" : 60 Ft.
N
Aquatic Habitat Restoration Plan
Prepared For CUSP / USFS
Designed by Gallagher
Checked by
Filename SP_R20_Restore_02_v2.SKF
Date April, 2010
Scale
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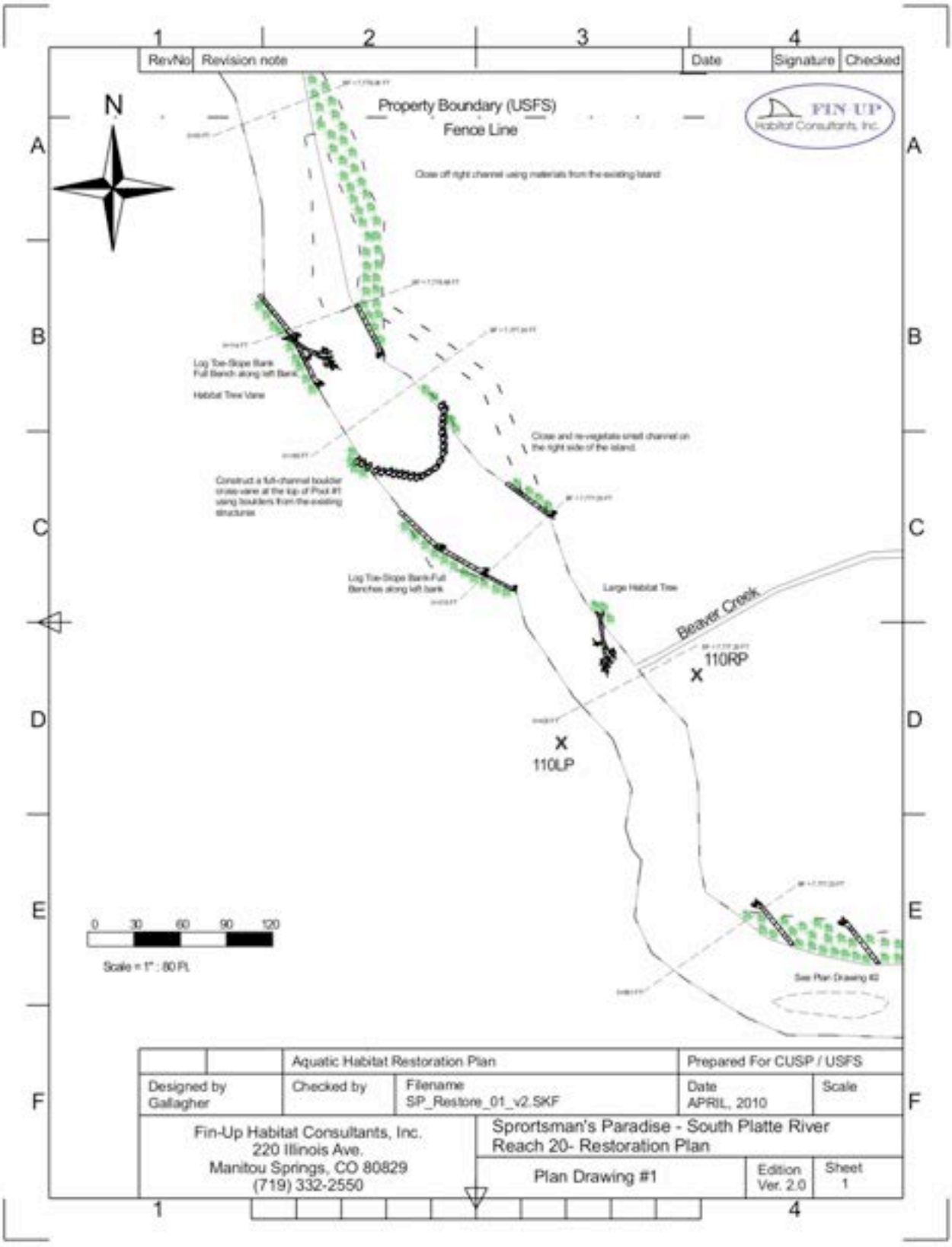
Sprortsman's Paradise - South Platte River
Reach 20- Restoration Plan
Plan Drawing #2
Edition Ver. 1.0
Sheet 1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RevNo
Revision note
Date
Signature
Checked
N
Property Boundary (USFS)
Fence Line
FIN UP
Habitat Consultants, Inc.
Close off right channel using materials from the existing island
Log Toe-Slope Bank
Full Bench along left Bank
Habitat Tree Vane
Close and re-vegetate small channel on the right side of the island.
Construct a full-channel boulder cross-vane at the top of Pool #1 using boulders from the existing structures
Log Toe-Slope Bank-Full Benches along left bank
Large Habitat Tree
Beaver Creek
110RP
110LP
0
30
60
90
120
Scale = 1" : 80 Ft.
See Plan Drawing #2
A
B
C
D
E
F
Aquatic Habitat Restoration Plan
Prepared For CUSP / USFS
Designed by
Gallagher
Checked by
Filename
SP_Restore_01_v2.SKF
Date
APRIL, 2010
Scale
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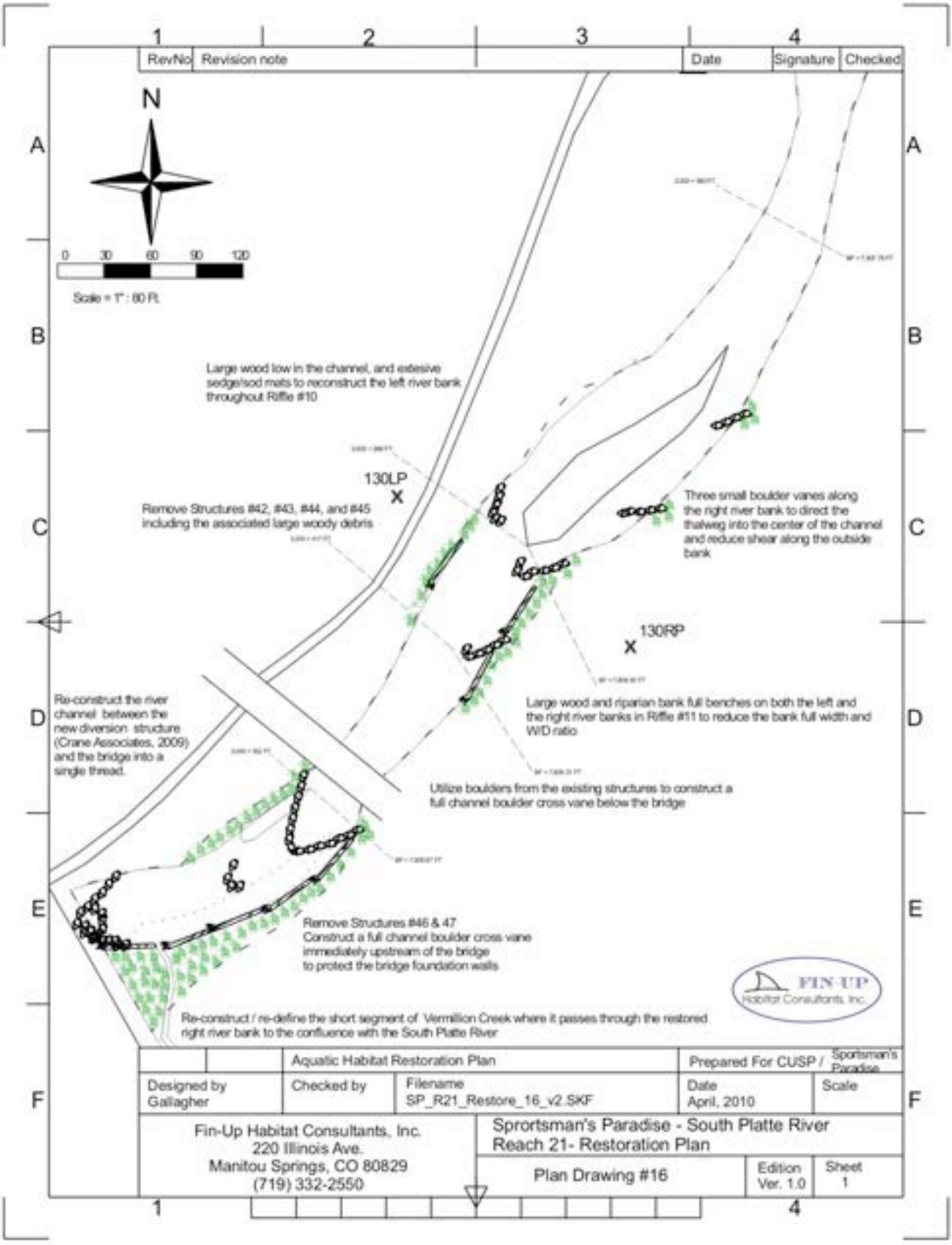
Plan Drawing #1
Edition
Ver. 2.0
Sheet
1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Revision note
Date
Signature
Checked
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0
30
60
90
120
Scale = 1" : 60 Ft.
Large wood low in the channel, and extesive sedge/sod mats to reconstruct the left river bank throughout Riffle #10
130LP
Remove Structures #42, #43, #44, and #45 including the associated large woody debris
Three small boulder vanes along the right river bank to direct the thalweg into the center of the channel and reduce shear along the outside bank
130RP
Large wood and riparian bank full benches on both the left and the right river banks in Riffle #11 to reduce the bank full width and W/D ratio
Re-construct the river channel between the new diversion structure (Crane Associates, 2009) and the bridge into a single thread.
Utilize boulders from the existing structures to construct a full channel boulder cross vane below the bridge
Remove Structures #46 & 47
Construct a full channel boulder cross vane immediately upstream of the bridge to protect the bridge foundation walls
FIN-UP Habitat Consultants, Inc.
Re-construct / re-define the short segment of Vermillion Creek where it passes through the restored right river bank to the confluence with the South Platte River
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Prepared For CUSP / Sportsman's Paradise
Designed by Gallagher
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Filename SP_R21_Restore_16_v2.SKF
Date April, 2010
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Reach 21- Restoration Plan
Plan Drawing #16
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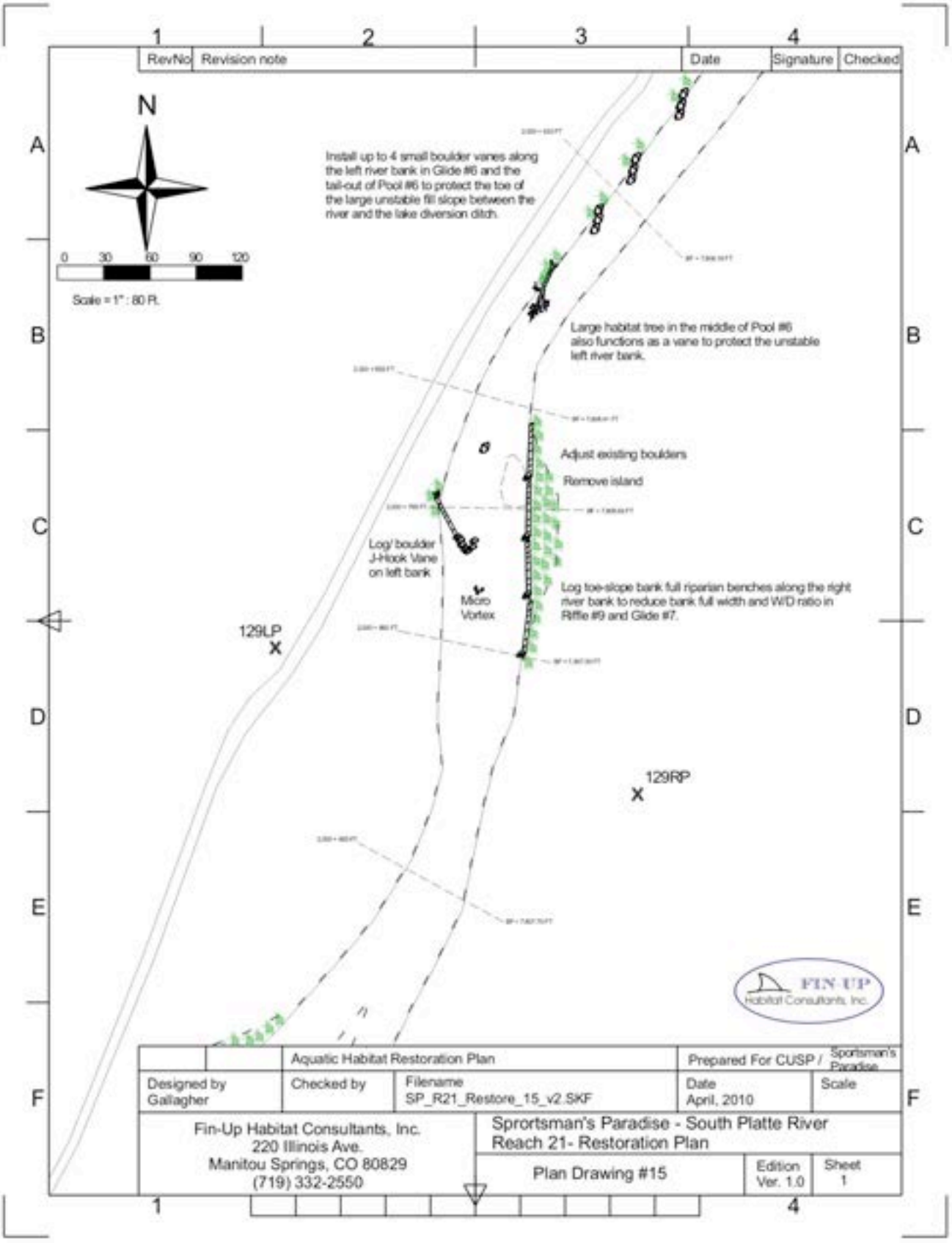
Sheet 1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Revision note
Date
Signature
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N
0 30 60 90 120
Scale = 1" : 80 Ft.
Install up to 4 small boulder vanes along the left river bank in Glide #6 and the tail-out of Pool #6 to protect the toe of the large unstable fill slope between the river and the lake diversion ditch.
Large habitat tree in the middle of Pool #6 also functions as a vane to protect the unstable left river bank.
Adjust existing boulders
Remove island
Log/ boulder J-Hook Vane on left bank
Micro Vortex
Log toe-slope bank full riparian benches along the right river bank to reduce bank full width and W/D ratio in Riffle #9 and Glide #7.
129LP
129RP
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Filename SP_R21_Restore_15_v2.SKF
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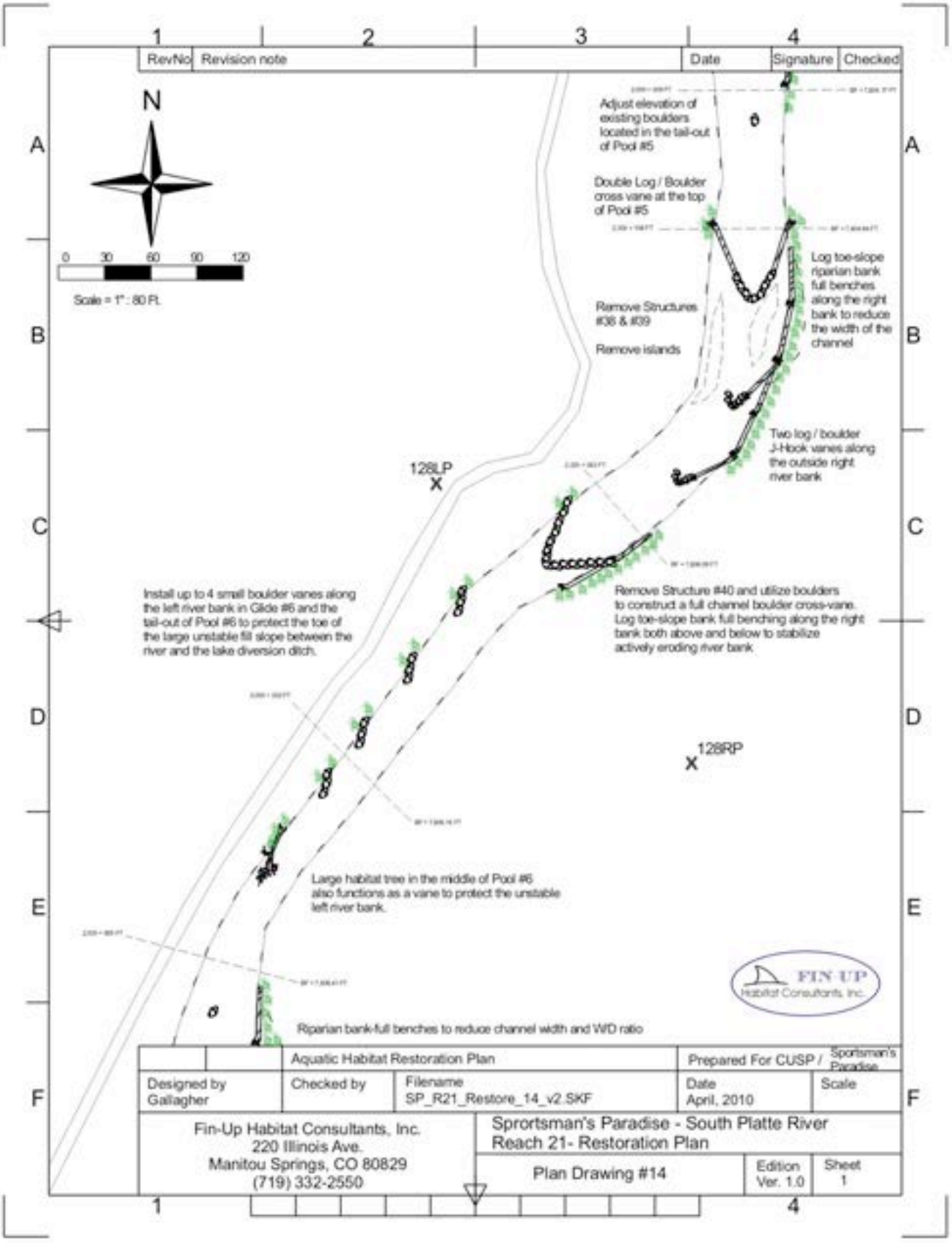
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Signature
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N
0 30 60 90 120
Scale = 1" : 60 Ft.
Adjust elevation of existing boulders located in the tail-out of Pool #5
Double Log / Boulder cross vane at the top of Pool #5
Log toe-slope riparian bank full benches along the right bank to reduce the width of the channel
Remove Structures #38 & #39
Remove islands
Two log / boulder J-Hook vanes along the outside right river bank
128LP
Install up to 4 small boulder vanes along the left river bank in Glide #6 and the tail-out of Pool #6 to protect the toe of the large unstable fill slope between the river and the lake diversion ditch.
Remove Structure #40 and utilize boulders to construct a full channel boulder cross-vane. Log toe-slope bank full benching along the right bank both above and below to stabilize actively eroding river bank
128RP
Large habitat tree in the middle of Pool #6 also functions as a vane to protect the unstable left river bank.
Riparian bank-full benches to reduce channel width and W/D ratio
FIN UP
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Filename SP_R21_Restore_14_v2.SKF
Date April, 2010
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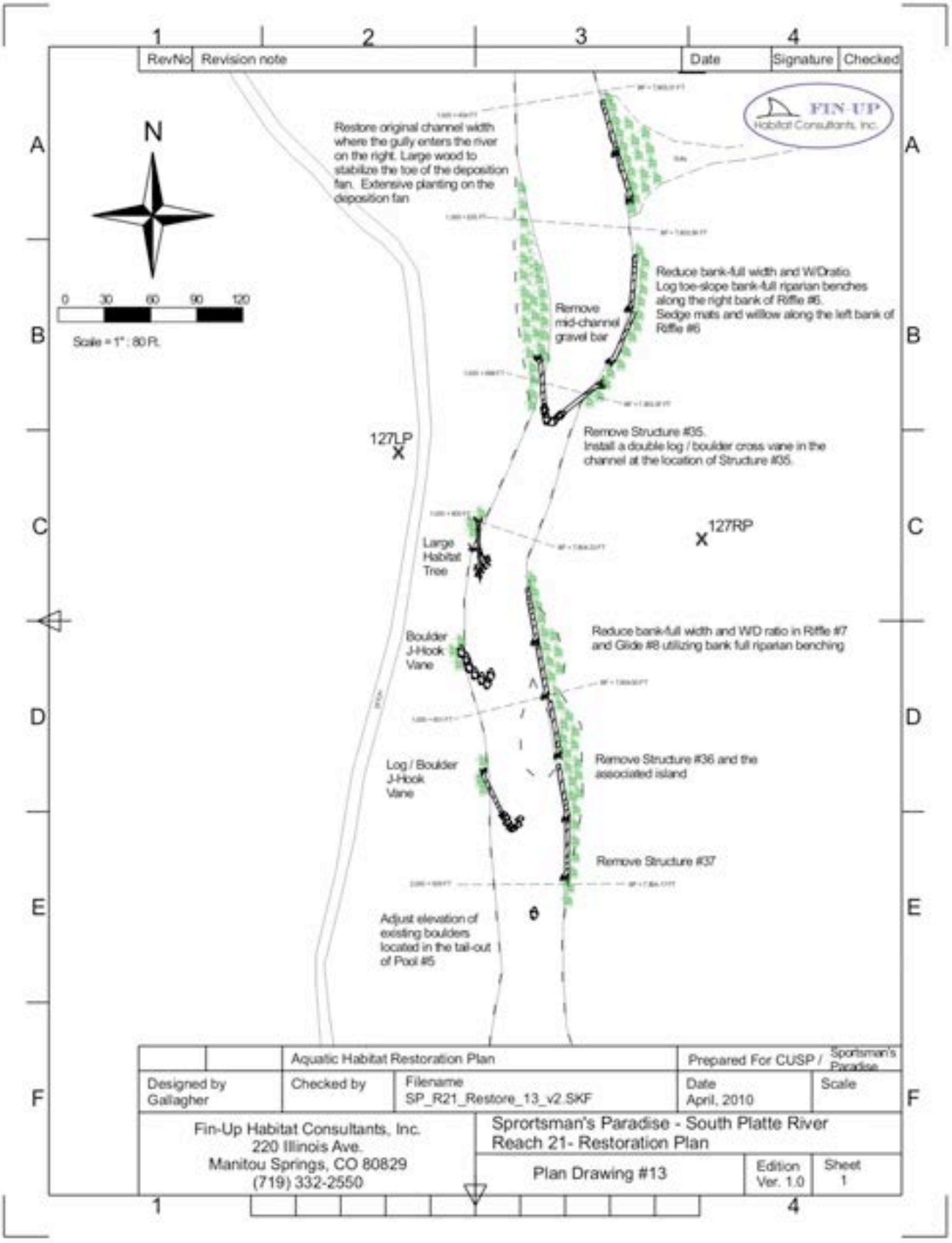
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Signature
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FIN-UP
Habitat Consultants, Inc.
N
0 30 60 90 120
Scale = 1" : 80 Ft.
Restore original channel width where the gully enters the river on the right. Large wood to stabilize the toe of the deposition fan. Extensive planting on the deposition fan
Reduce bank-full width and W/Dratio. Log toe-slope bank-full riparian benches along the right bank of Riffle #6. Sedge mats and willow along the left bank of Riffle #6
Remove mid-channel gravel bar
Remove Structure #35. Install a double log / boulder cross vane in the channel at the location of Structure #35.
127LP
127RP
Large Habitat Tree
Boulder J-Hook Vane
Reduce bank-full width and W/D ratio in Riffle #7 and Glide #8 utilizing bank full riparian benching
Log / Boulder J-Hook Vane
Remove Structure #36 and the associated island
Remove Structure #37
Adjust elevation of existing boulders located in the tail-out of Pool #5
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Prepared For CUSP / Sportsman's Paradise
Designed by Gallagher
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Filename SP_R21_Restore_13_v2.SKF
Date April, 2010
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Edition Ver. 1.0
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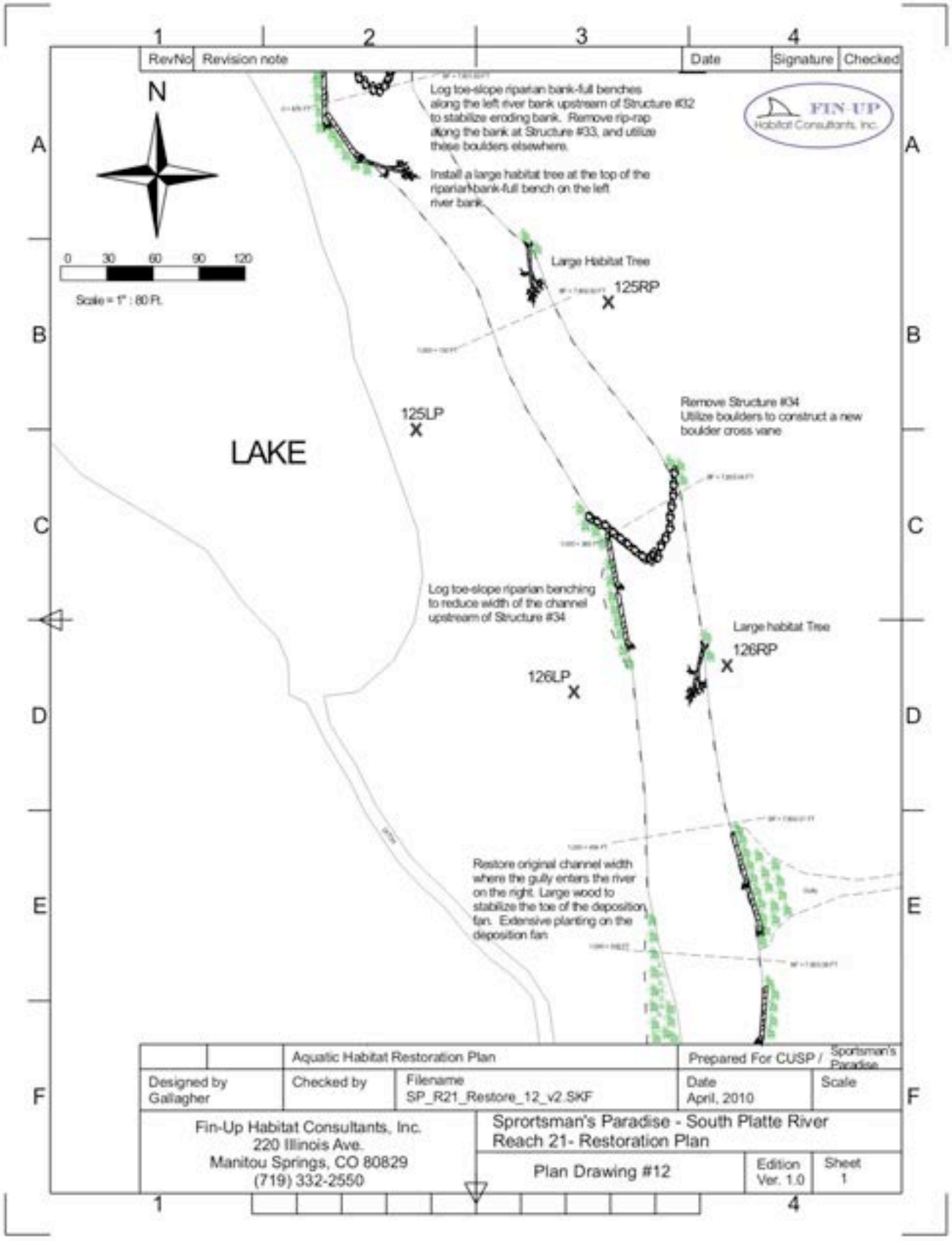
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0 30 60 90 120
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Log toe-slope riparian bank-full benches along the left river bank upstream of Structure #32 to stabilize eroding bank. Remove rip-rap along the bank at Structure #33, and utilize these boulders elsewhere.
Install a large habitat tree at the top of the riparian/bank-full bench on the left river bank.
Large Habitat Tree
125RP
125LP
LAKE
Remove Structure #34
Utilize boulders to construct a new boulder cross vane
Log toe-slope riparian benching to reduce width of the channel upstream of Structure #34
Large habitat Tree
126RP
126LP
Restore original channel width where the gully enters the river on the right. Large wood to stabilize the toe of the deposition fan. Extensive planting on the deposition fan
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Filename SP_R21_Restore_12_v2.SKF
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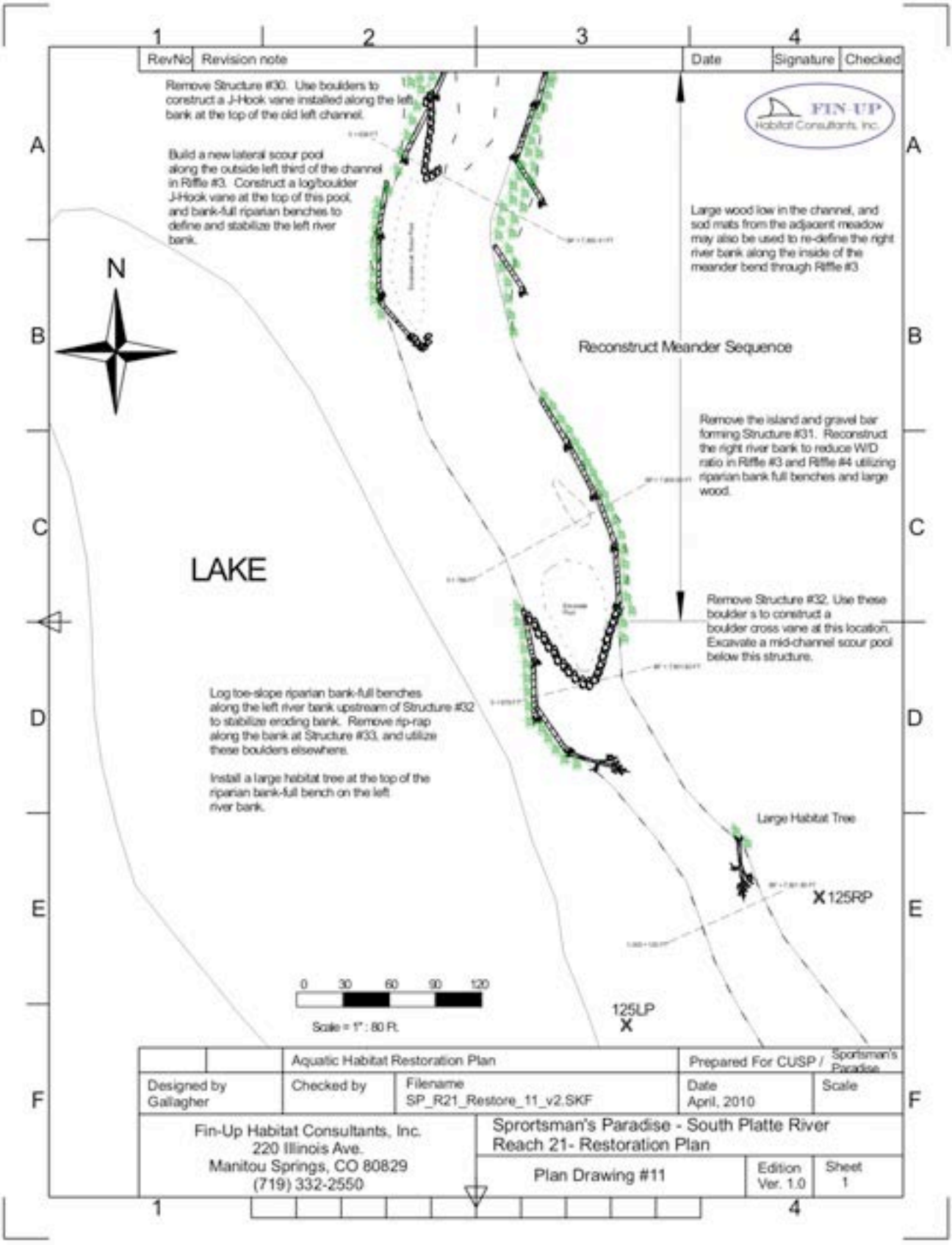
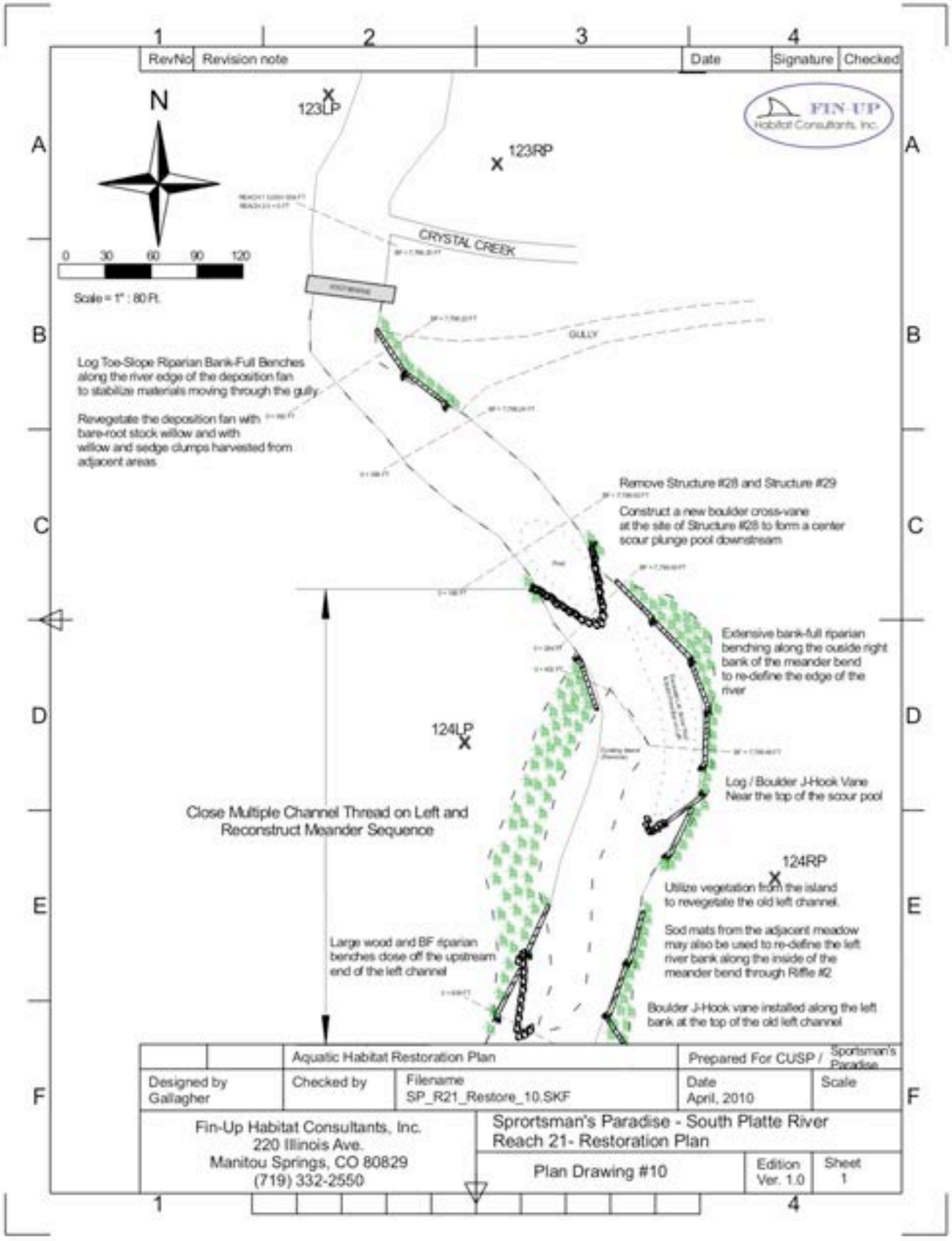
Sprortsman's Paradise - South Platte River
Reach 21- Restoration Plan
Plan Drawing #12
Edition Ver. 1.0
Sheet 1


RevNo
Revision note
Date
Signature
Checked
Remove Structure #30. Use boulders to construct a J-Hook vane installed along the left bank at the top of the old left channel.
Build a new lateral scour pool along the outside left third of the channel in Riffle #3. Construct a log/boulder J-Hook vane at the top of this pool, and bank-full riparian benches to define and stabilize the left river bank.
FIN-UP
Habitat Consultants, Inc.
Large wood low in the channel, and sod mats from the adjacent meadow may also be used to re-define the right river bank along the inside of the meander bend through Riffle #3
N
Reconstruct Meander Sequence
Remove the island and gravel bar forming Structure #31. Reconstruct the right river bank to reduce W/D ratio in Riffle #3 and Riffle #4 utilizing riparian bank full benches and large wood.
LAKE
Remove Structure #32. Use these boulder s to construct a boulder cross vane at this location. Excavate a mid-channel scour pool below this structure.
Log toe-slope riparian bank-full benches along the left river bank upstream of Structure #32 to stabilize eroding bank. Remove rip-rap along the bank at Structure #33, and utilize these boulders elsewhere.
Install a large habitat tree at the top of the riparian bank-full bench on the left river bank.
Large Habitat Tree
X125RP
0 30 60 90 120
Scale = 1" : 80 ft.
125LP
Aquatic Habitat Restoration Plan
Prepared For CUSP / Sportsman's Paradise
Designed by Gallagher
Checked by
Filename SP_R21_Restore_11_v2.SKF
Date April, 2010
Scale
Fin-Up Habitat Consultants, Inc.
220 Illinois Ave.
Manitou Springs, CO 80829
(719) 332-2550
Sprortsman's Paradise - South Platte River
Reach 21- Restoration Plan
Plan Drawing #11
Edition Ver. 1.0
Sheet 1


RevNo
Revision note
Date
Signature
Checked
N
123LP
123RP
FIN-UP
Habitat Consultants, Inc.
CRYSTAL CREEK
GULLY
0 30 60 90 120
Scale = 1" : 80 Ft.
Log Toe-Slope Riparian Bank-Full Benches along the river edge of the deposition fan to stabilize materials moving through the gully.
Revegetate the deposition fan with bare-root stock willow and with willow and sedge clumps harvested from adjacent areas.
Remove Structure #28 and Structure #29
Construct a new boulder cross-vane at the site of Structure #28 to form a center scour plunge pool downstream
Extensive bank-full riparian benching along the ouside right bank of the meander bend to re-define the edge of the river
124LP
Log / Boulder J-Hook Vane Near the top of the scour pool
Close Multiple Channel Thread on Left and Reconstruct Meander Sequence
124RP
Utilize vegetation from the island to revegetate the old left channel.
Sod mats from the adjacent meadow may also be used to re-define the left river bank along the inside of the meander bend through Riffle #2
Large wood and BF riparian benches close off the upstream end of the left channel
Boulder J-Hook vane installed along the left bank at the top of the old left channel
Aquatic Habitat Restoration Plan
Prepared For CUSP / Sportsman's Paradise
Designed by Gallagher
Checked by
Filename SP_R21_Restore_10.SKF
Date April, 2010
Scale
Fin-Up Habitat Consultants, Inc.
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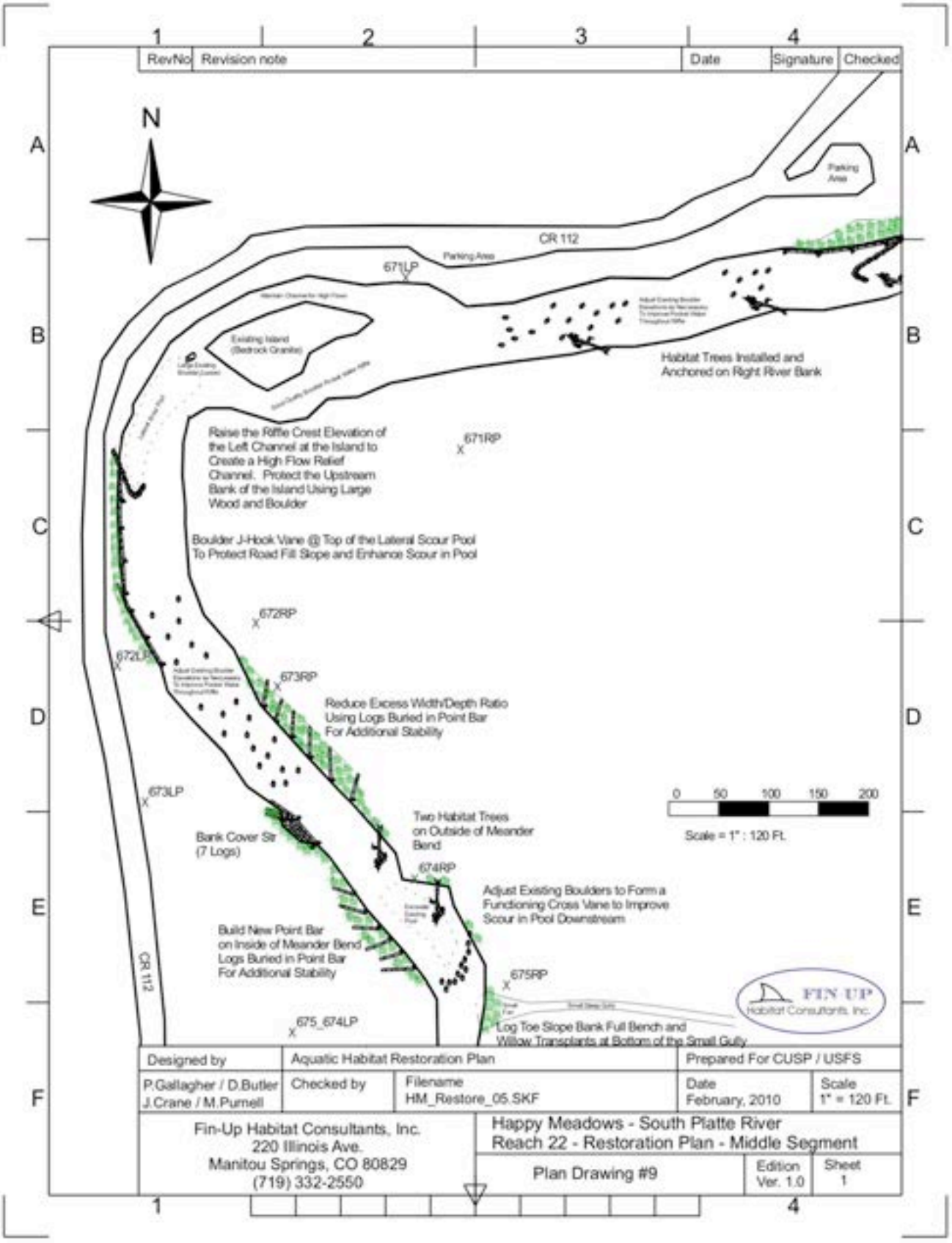
Sprortsman's Paradise - South Platte River
Reach 21- Restoration Plan
Plan Drawing #10
Edition Ver. 1.0
Sheet 1


RevNo
Revision note
Date
Signature
Checked
N
CR 112
Parking Area
671LP
Existing Island (Bedrock Granite)
Habitat Trees Installed and Anchored on Right River Bank
Raise the Riffle Crest Elevation of the Left Channel at the Island to Create a High Flow Relief Channel. Protect the Upstream Bank of the Island Using Large Wood and Boulder
671RP
Boulder J-Hook Vane @ Top of the Lateral Scour Pool To Protect Road Fill Slope and Enhance Scour in Pool
672RP
672LP
673RP
Reduce Excess Width/Depth Ratio Using Logs Buried in Point Bar For Additional Stability
673LP
0 50 100 150 200
Scale = 1" : 120 Ft.
Two Habitat Trees on Outside of Meander Bend
Bank Cover Str (7 Logs)
674RP
Adjust Existing Boulders to Form a Functioning Cross Vane to Improve Scour in Pool Downstream
Build New Point Bar on Inside of Meander Bend Logs Buried in Point Bar For Additional Stability
675RP
675_674LP
Log Toe Slope Bank Full Bench and Willow Transplants at Bottom of the Small Gully
FIN UP Habitat Consultants, Inc.
Designed by
P.Gallagher / D.Butler
J.Crane / M.Purnell
Aquatic Habitat Restoration Plan
Checked by
Filename
HM_Restore_05.SKF
Prepared For CUSP / USFS
Date
February, 2010
Scale
1" = 120 Ft.
Fin-Up Habitat Consultants, Inc.
220 Illinois Ave.
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Happy Meadows - South Platte River
Reach 22 - Restoration Plan - Middle Segment
Plan Drawing #9
Edition
Ver. 1.0
Sheet
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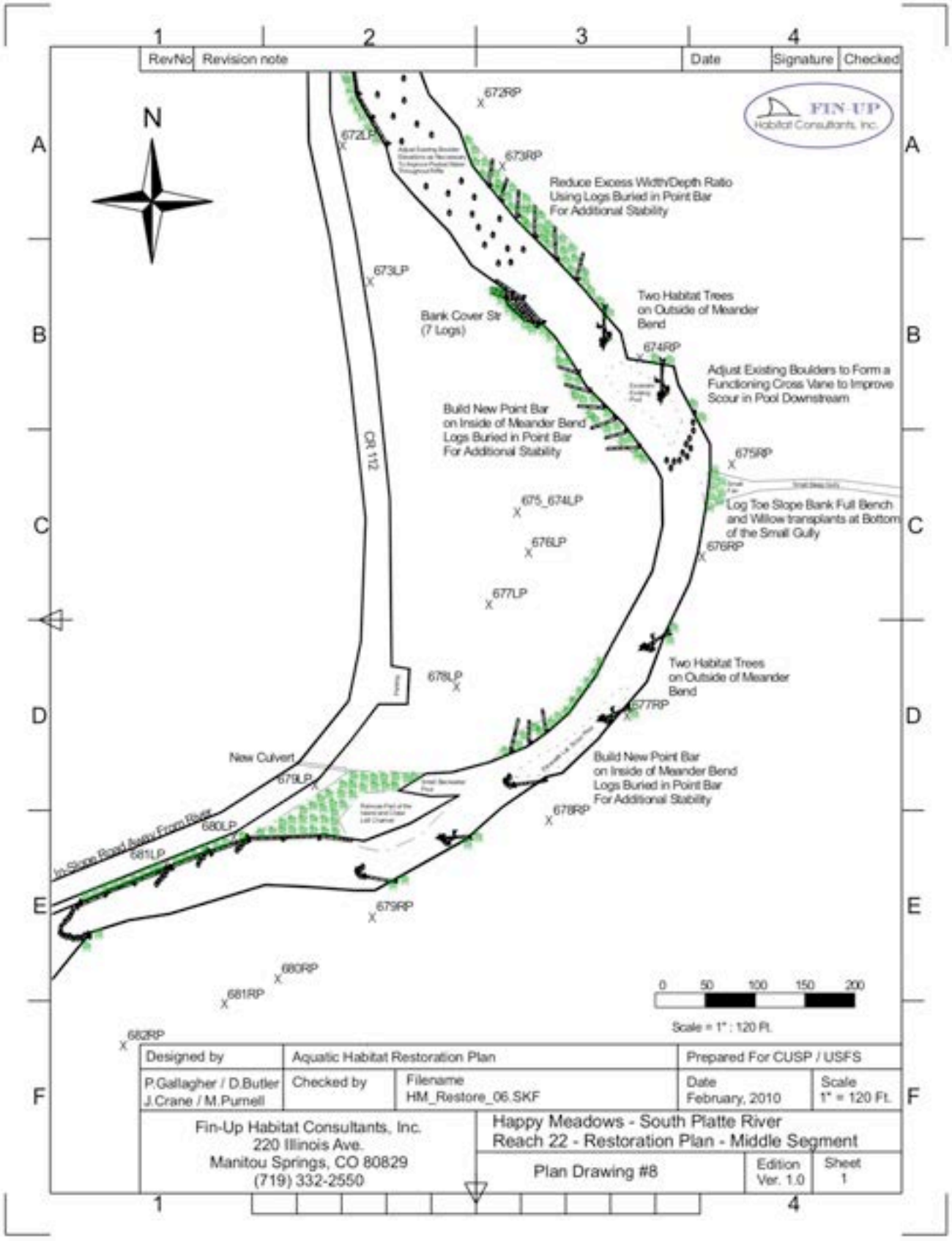
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Revision note
Date
Signature
Checked
FIN-UP
Habitat Consultants, Inc.
N
672RP
672LP
673RP
673LP
674RP
675RP
675_674LP
676LP
676RP
677LP
677RP
678LP
678RP
679LP
679RP
680LP
680RP
681LP
681RP
682RP
Reduce Excess Width/Depth Ratio
Using Logs Buried in Point Bar
For Additional Stability
Two Habitat Trees
on Outside of Meander
Bend
Bank Cover Str
(7 Logs)
Adjust Existing Boulders to Form a
Functioning Cross Vane to Improve
Scour in Pool Downstream
Build New Point Bar
on Inside of Meander Bend
Logs Buried in Point Bar
For Additional Stability
Log Toe Slope Bank Full Bench
and Willow transplants at Bottom
of the Small Gully
Two Habitat Trees
on Outside of Meander
Bend
Build New Point Bar
on Inside of Meander Bend
Logs Buried in Point Bar
For Additional Stability
New Culvert
CR 112
0
50
100
150
200
Scale = 1" : 120 Ft.
Designed by
P.Gallagher / D.Butler
J.Crane / M.Purnell
Aquatic Habitat Restoration Plan
Checked by
Filename
HM_Restore_06.SKF
Prepared For CUSP / USFS
Date
February, 2010
Scale
1" = 120 Ft.
Fin-Up Habitat Consultants, Inc.
220 Illinois Ave.
Manitou Springs, CO 80829
(719) 332-2550
Happy Meadows - South Platte River
Reach 22 - Restoration Plan - Middle Segment
Plan Drawing #8
Edition
Ver. 1.0
Sheet
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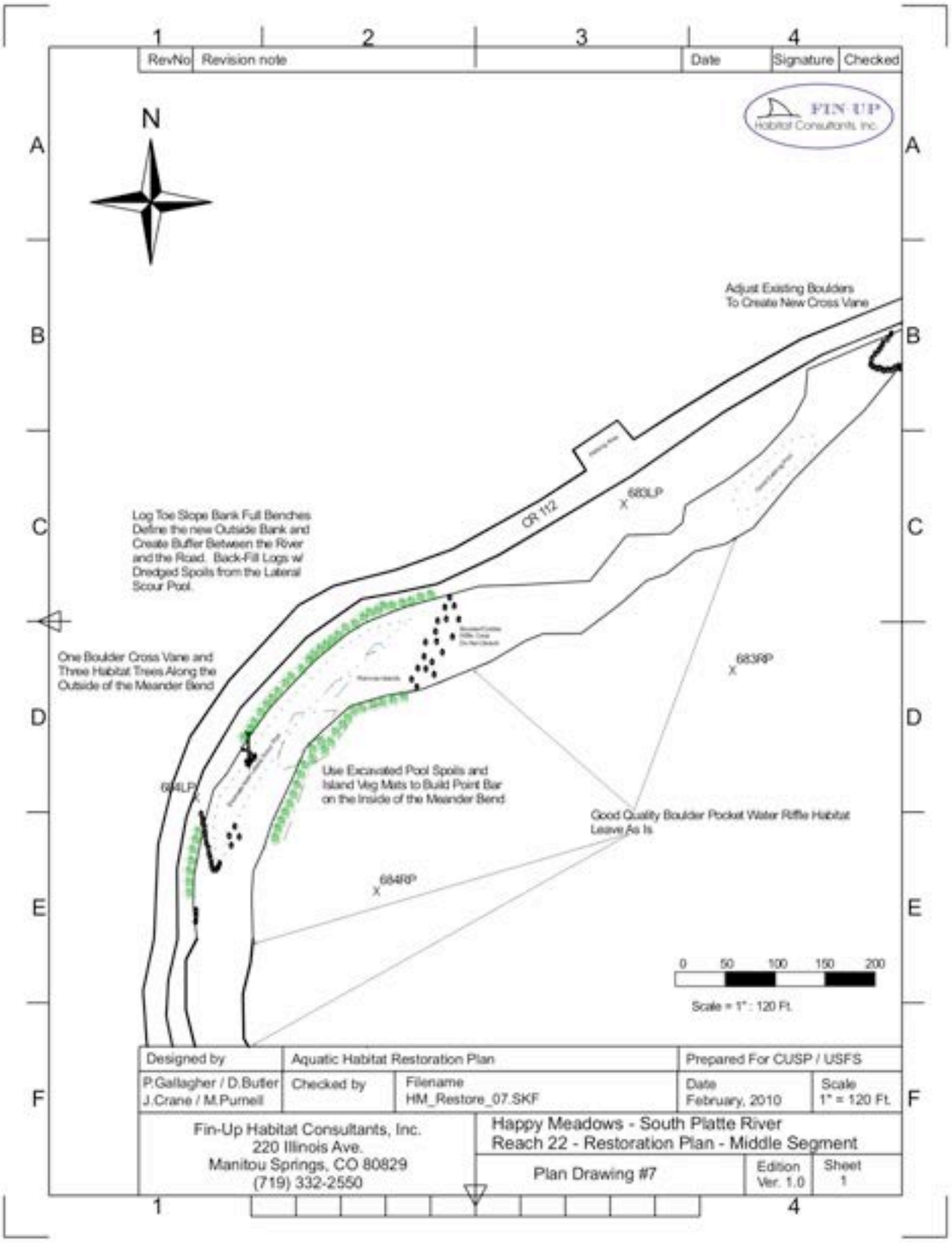
RevNo
Revision note
Date
Signature
Checked
FIN-UP
Habitat Consultants, Inc.
N
Adjust Existing Boulders
To Create New Cross Vane
Log Toe Slope Bank Full Benches
Define the new Outside Bank and
Create Buffer Between the River
and the Road. Back-Fill Logs w/
Dredged Spoils from the Lateral
Scour Pool.
CR 112
683LP
One Boulder Cross Vane and
Three Habitat Trees Along the
Outside of the Meander Bend
683RP
Use Excavated Pool Spoils and
Island Veg Mats to Build Point Bar
on the Inside of the Meander Bend
684LP
Good Quality Boulder Pocket Water Riffle Habitat
Leave As Is
684RP
0
50
100
150
200
Scale = 1" : 120 Ft.
Designed by
P.Gallagher / D.Butler
J.Crane / M.Purnell
Aquatic Habitat Restoration Plan
Checked by
Filename
HM_Restore_07.SKF
Prepared For CUSP / USFS
Date
February, 2010
Scale
1" = 120 Ft.
Fin-Up Habitat Consultants, Inc.
220 Illinois Ave.
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Happy Meadows - South Platte River
Reach 22 - Restoration Plan - Middle Segment
Plan Drawing #7
Edition
Ver. 1.0
Sheet
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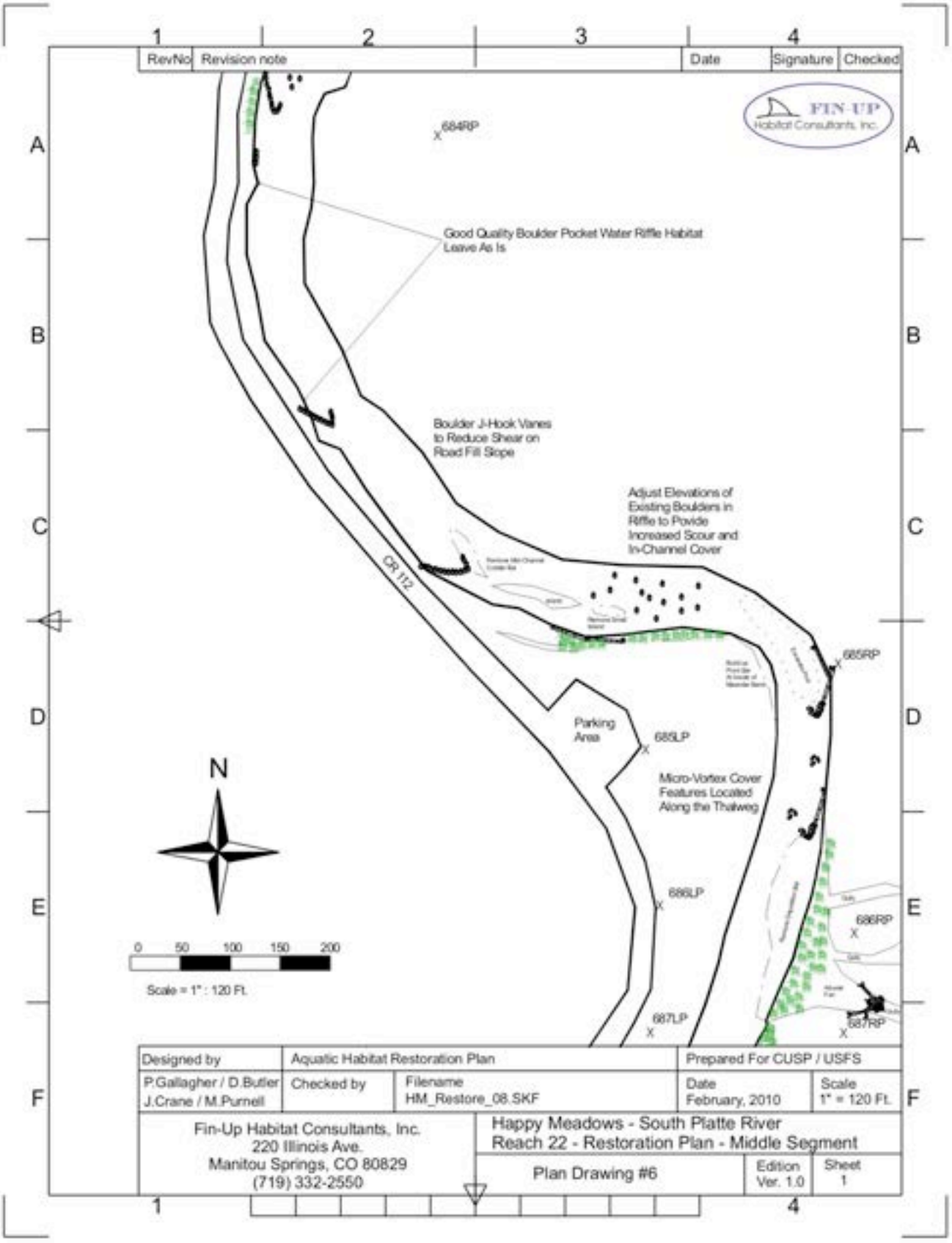
RevNo
Revision note
Date
Signature
Checked
FIN-UP
Habitat Consultants, Inc.
684RP
Good Quality Boulder Pocket Water Riffle Habitat
Leave As Is
Boulder J-Hook Vanes
to Reduce Shear on
Road Fill Slope
Adjust Elevations of
Existing Boulders in
Riffle to Povide
Increased Scour and
In-Channel Cover
CR 112
685RP
Parking
Area
685LP
Micro-Vortex Cover
Features Located
Along the Thalweg
686LP
686RP
687LP
687RP
N
0
50
100
150
200
Scale = 1" : 120 Ft.
Designed by
P.Gallagher / D.Butler
J.Crane / M.Purnell
Aquatic Habitat Restoration Plan
Checked by
Filename
HM_Restore_08.SKF
Prepared For CUSP / USFS
Date
February, 2010
Scale
1" = 120 Ft.
Fin-Up Habitat Consultants, Inc.
220 Illinois Ave.
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Happy Meadows - South Platte River
Reach 22 - Restoration Plan - Middle Segment
Plan Drawing #6
Edition
Ver. 1.0
Sheet
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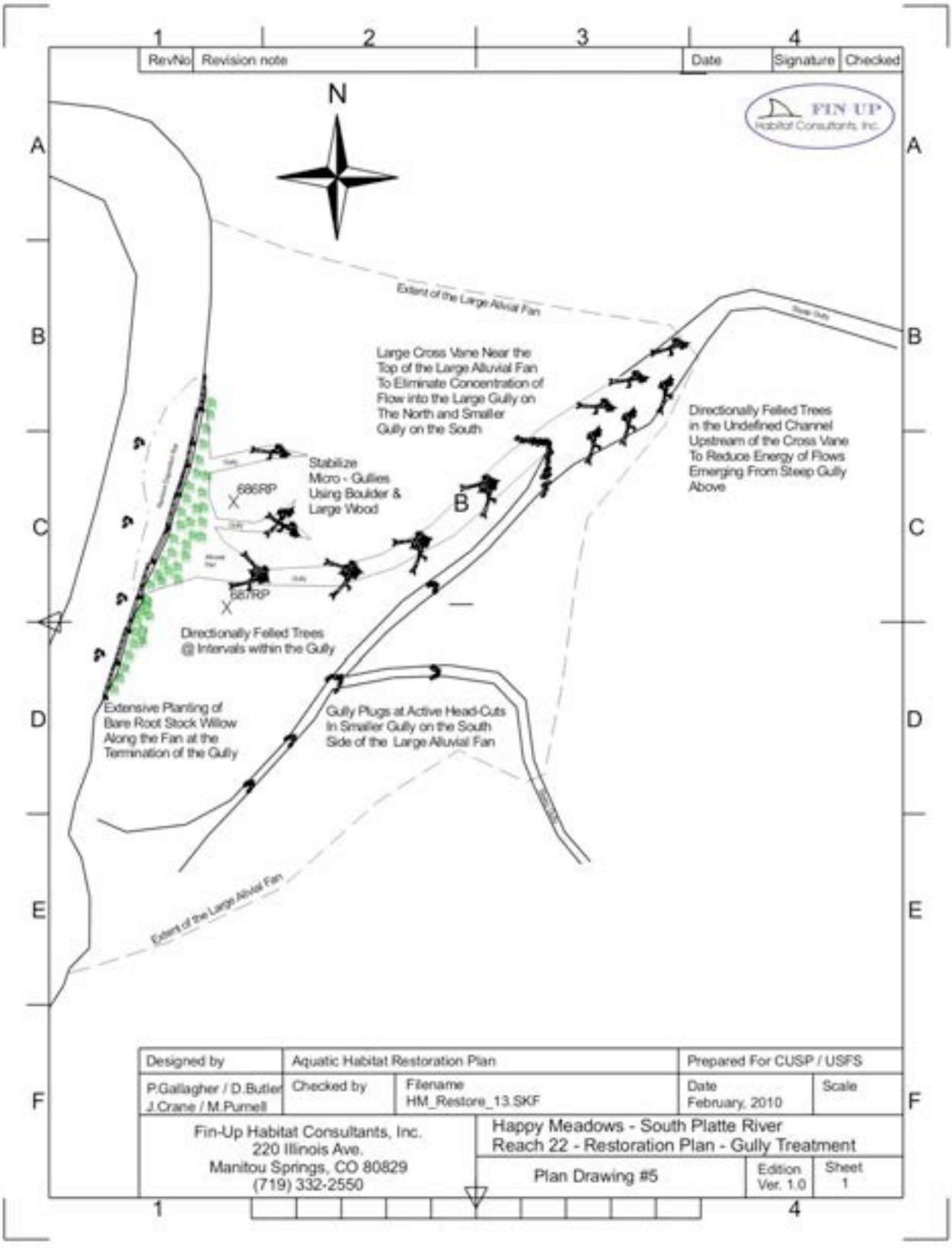
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4
RevNo
Revision note
Date
Signature
Checked
N
FIN UP
Habitat Consultants, Inc.
A
B
C
D
E
F
Extent of the Large Alluvial Fan
Large Cross Vane Near the Top of the Large Alluvial Fan To Eliminate Concentration of Flow into the Large Gully on The North and Smaller Gully on the South
Directionally Felled Trees in the Undefined Channel Upstream of the Cross Vane To Reduce Energy of Flows Emerging From Steep Gully Above
Stabilize Micro - Gullies Using Boulder & Large Wood
686RP
687RP
Directionally Felled Trees @ Intervals within the Gully
Extensive Planting of Bare Root Stock Willow Along the Fan at the Termination of the Gully
Gully Plugs at Active Head-Cuts In Smaller Gully on the South Side of the Large Alluvial Fan
Designed by
P.Gallagher / D.Butler
J.Crane / M.Purnell
Aquatic Habitat Restoration Plan
Checked by
Filename
HM_Restore_13.SKF
Prepared For CUSP / USFS
Date
February, 2010
Scale
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Happy Meadows - South Platte River
Reach 22 - Restoration Plan - Gully Treatment
Plan Drawing #5
Edition
Ver. 1.0
Sheet
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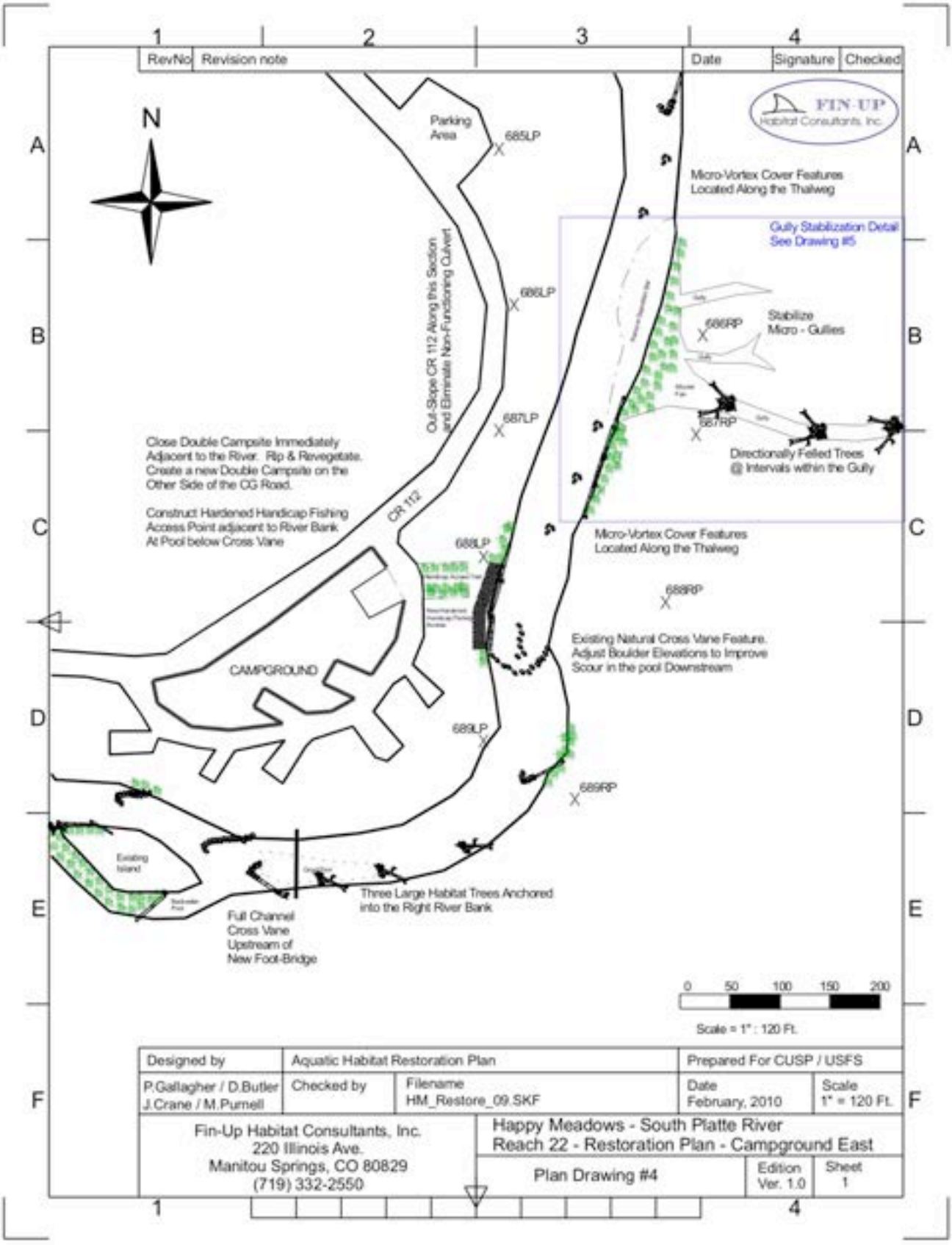
RevNo
Revision note
Date
Signature
Checked
FIN-UP
Habitat Consultants, Inc.
N
Parking Area
685LP
686LP
687LP
688LP
688RP
689LP
689RP
686RP
687RP
Micro-Vortex Cover Features Located Along the Thalweg
Gully Stabilization Detail See Drawing #5
Stabilize Micro - Gullies
Directionally Felled Trees @ Intervals within the Gully
Out-Slope CR 112 Along this Section and Eliminate Non-Functioning Culvert
CR 112
Close Double Campsite Immediately Adjacent to the River. Rip & Revegetate. Create a new Double Campsite on the Other Side of the CG Road.
Construct Hardened Handicap Fishing Access Point adjacent to River Bank At Pool below Cross Vane
CAMPGROUND
Micro-Vortex Cover Features Located Along the Thalweg
Existing Natural Cross Vane Feature. Adjust Boulder Elevations to Improve Scour in the pool Downstream
Existing Island
Full Channel Cross Vane Upstream of New Foot-Bridge
Three Large Habitat Trees Anchored into the Right River Bank
0 50 100 150 200
Scale = 1" : 120 Ft.
Designed by
P.Gallagher / D.Butler
J.Crane / M.Purnell
Aquatic Habitat Restoration Plan
Checked by
Filename
HM_Restore_09.SKF
Prepared For CUSP / USFS
Date
February, 2010
Scale
1" = 120 Ft.
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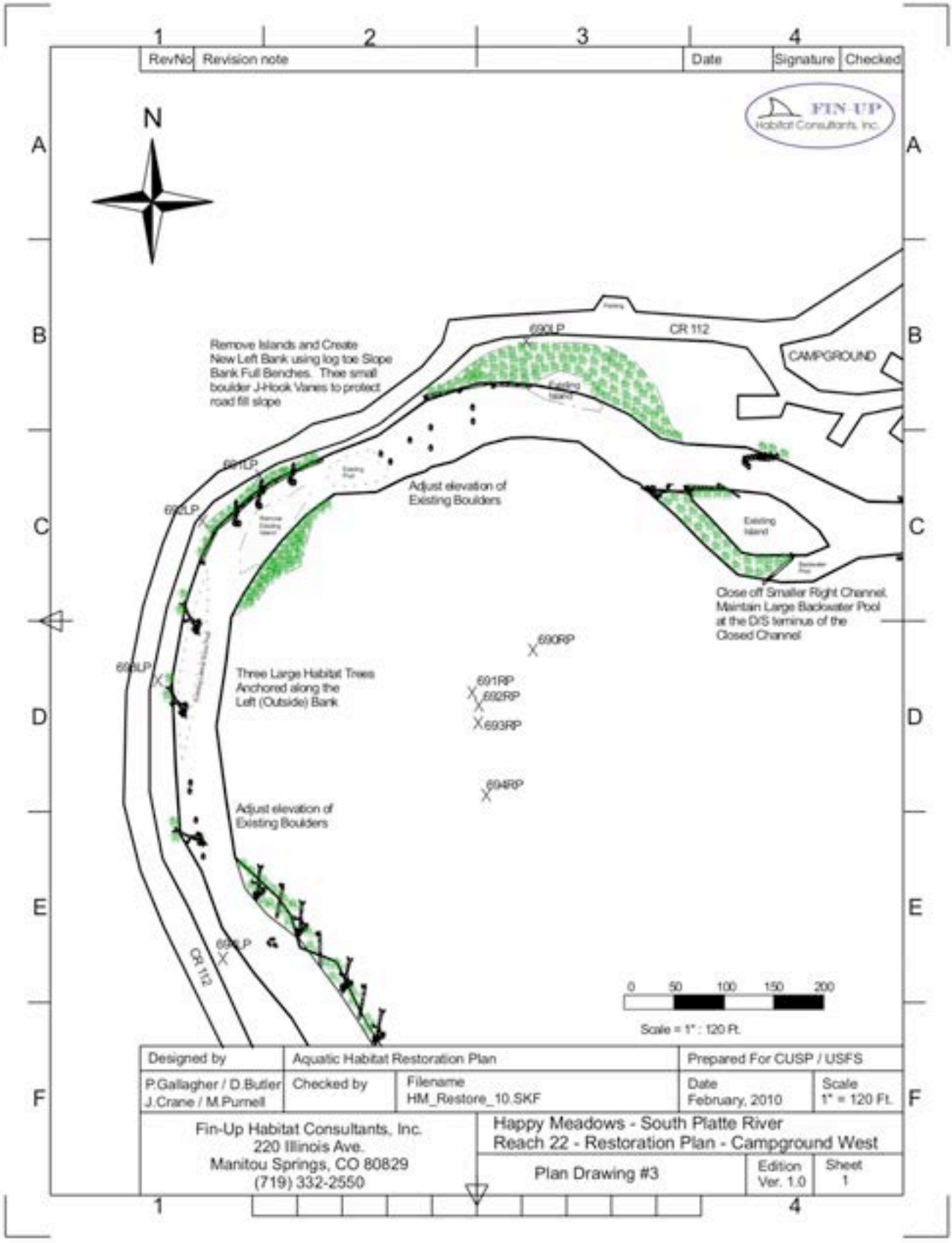
Happy Meadows - South Platte River
Reach 22 - Restoration Plan - Campground East
Plan Drawing #4
Edition
Ver. 1.0
Sheet
1


RevNo
Revision note
Date
Signature
Checked
FIN-UP
Habitat Consultants, Inc.
N
Remove Islands and Create New Left Bank using log toe Slope Bank Full Benches. Thee small boulder J-Hook Vanes to protect road fill slope
690LP
CR 112
CAMPGROUND
691LP
692LP
Adjust elevation of Existing Boulders
Existing Island
Close off Smaller Right Channel. Maintain Large Backwater Pool at the D/S terminus of the Closed Channel
690RP
691RP
692RP
693RP
694RP
695LP
Three Large Habitat Trees Anchored along the Left (Outside) Bank
Adjust elevation of Existing Boulders
695LP
CR 112
0 50 100 150 200
Scale = 1" : 120 Ft.
Designed by
P.Gallagher / D.Butler
J.Crane / M.Purnell
Aquatic Habitat Restoration Plan
Checked by
Filename
HM_Restore_10.SKF
Prepared For CUSP / USFS
Date
February, 2010
Scale
1" = 120 Ft.
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Happy Meadows - South Platte River
Reach 22 - Restoration Plan - Campground West
Plan Drawing #3
Edition
Ver. 1.0
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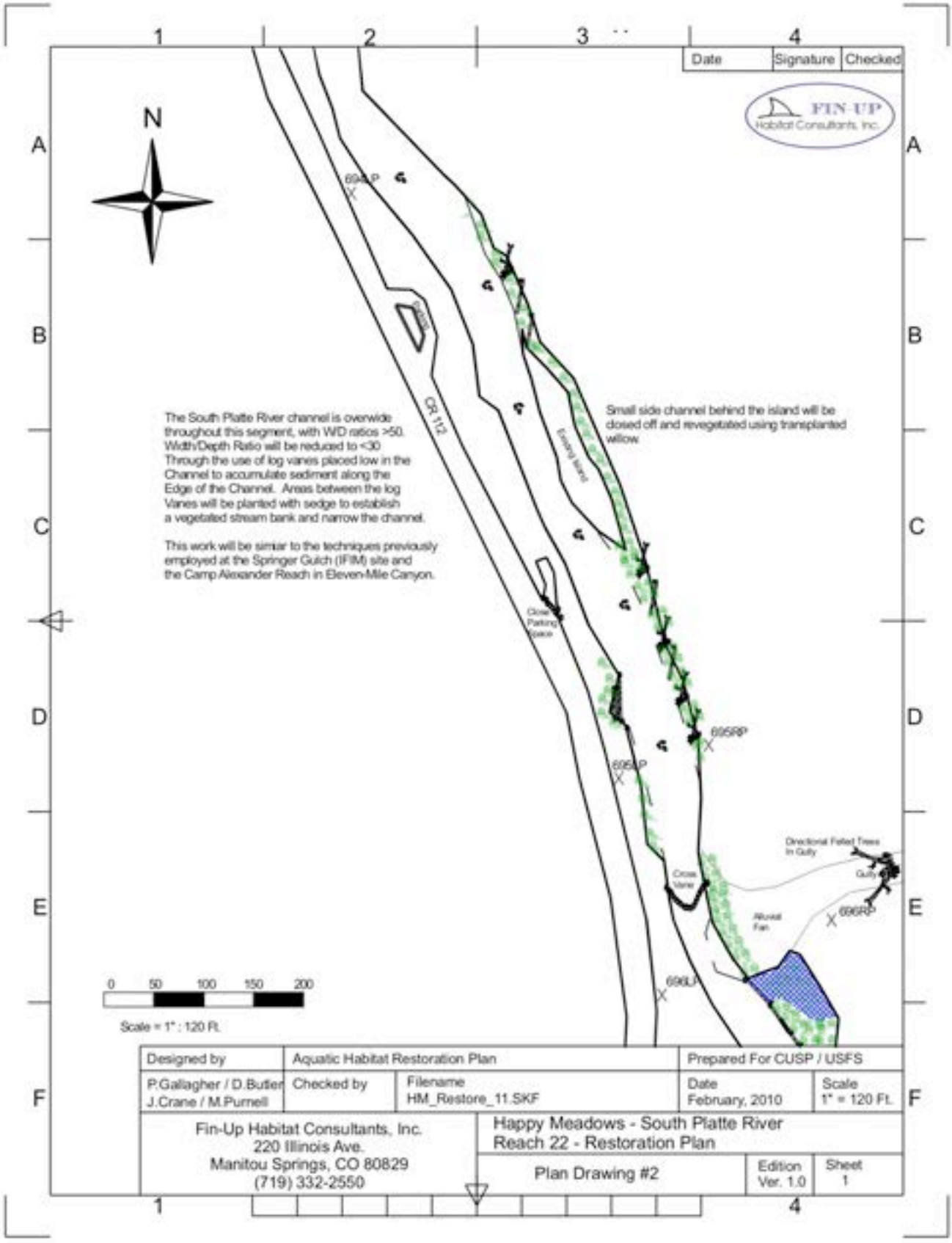
Date
Signature
Checked
FIN-UP
Habitat Consultants, Inc.
N
694LP
694RP
CR 112
Existing Island
Small side channel behind the island will be closed off and revegetated using transplanted willow
The South Platte River channel is overwide throughout this segment, with W/D ratios >50. Width/Depth Ratio will be reduced to <30 Through the use of log vanes placed low in the Channel to accumulate sediment along the Edge of the Channel. Areas between the log Vanes will be planted with sedge to establish a vegetated stream bank and narrow the channel.
This work will be simiar to the techniques previously employed at the Springer Gulch (IFIM) site and the Camp Alexander Reach in Eleven-Mile Canyon.
Close Parking Space
695RP
695LP
Directional Felled Trees In Gully
Gully
Cross Vane
Alluvial Fan
696RP
696LP
0 50 100 150 200
Scale = 1" : 120 Ft.
Designed by
P.Gallagher / D.Butler
J.Crane / M.Purnell
Aquatic Habitat Restoration Plan
Checked by
Filename
HM_Restore_11.SKF
Prepared For CUSP / USFS
Date
February, 2010
Scale
1" = 120 Ft.
Fin-Up Habitat Consultants, Inc.
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Happy Meadows - South Platte River
Reach 22 - Restoration Plan
Plan Drawing #2
Edition
Ver. 1.0
Sheet
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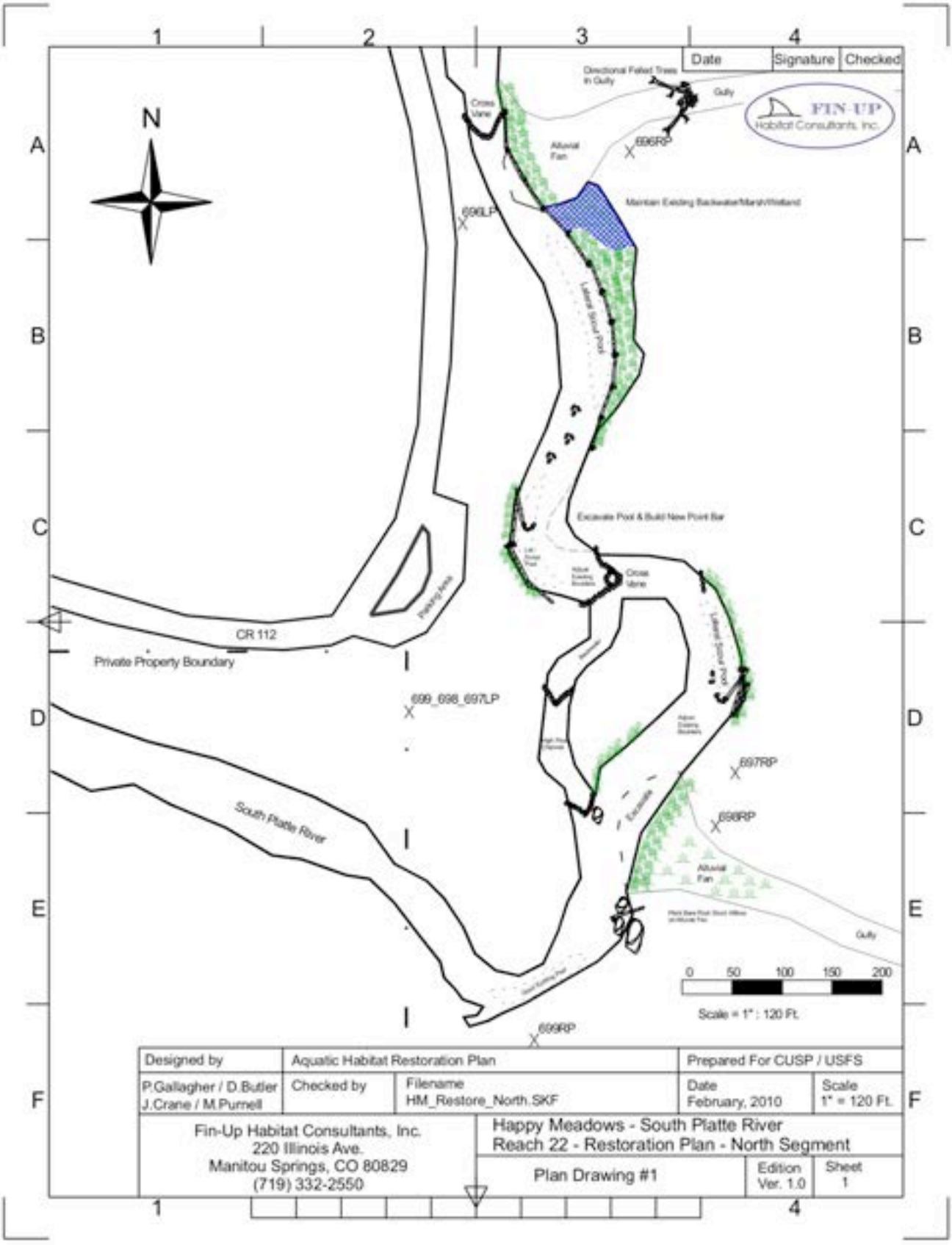
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2
3
4
A
B
C
D
E
F
Date
Signature
Checked
N
FIN-UP
Habitat Consultants, Inc.
Directional Felled Trees In Gully
Gully
Cross Vane
Alluvial Fan
696RP
696LP
Maintain Existing Backwater/Marsh/Wetland
Lateral Scour Pool
Excavate Pool & Build New Point Bar
Cross Vane
Lateral Scour Pool
CR 112
Private Property Boundary
Parking Area
699_698_697LP
South Platte River
697RP
698RP
Excavate
Alluvial Fan
Gully
699RP
0
50
100
150
200
Scale = 1" : 120 Ft.
Designed by
P.Gallagher / D.Butler
J.Crane / M.Purnell
Aquatic Habitat Restoration Plan
Checked by
Filename
HM_Restore_North.SKF
Prepared For CUSP / USFS
Date
February, 2010
Scale
1" = 120 Ft.
Fin-Up Habitat Consultants, Inc.
220 Illinois Ave.
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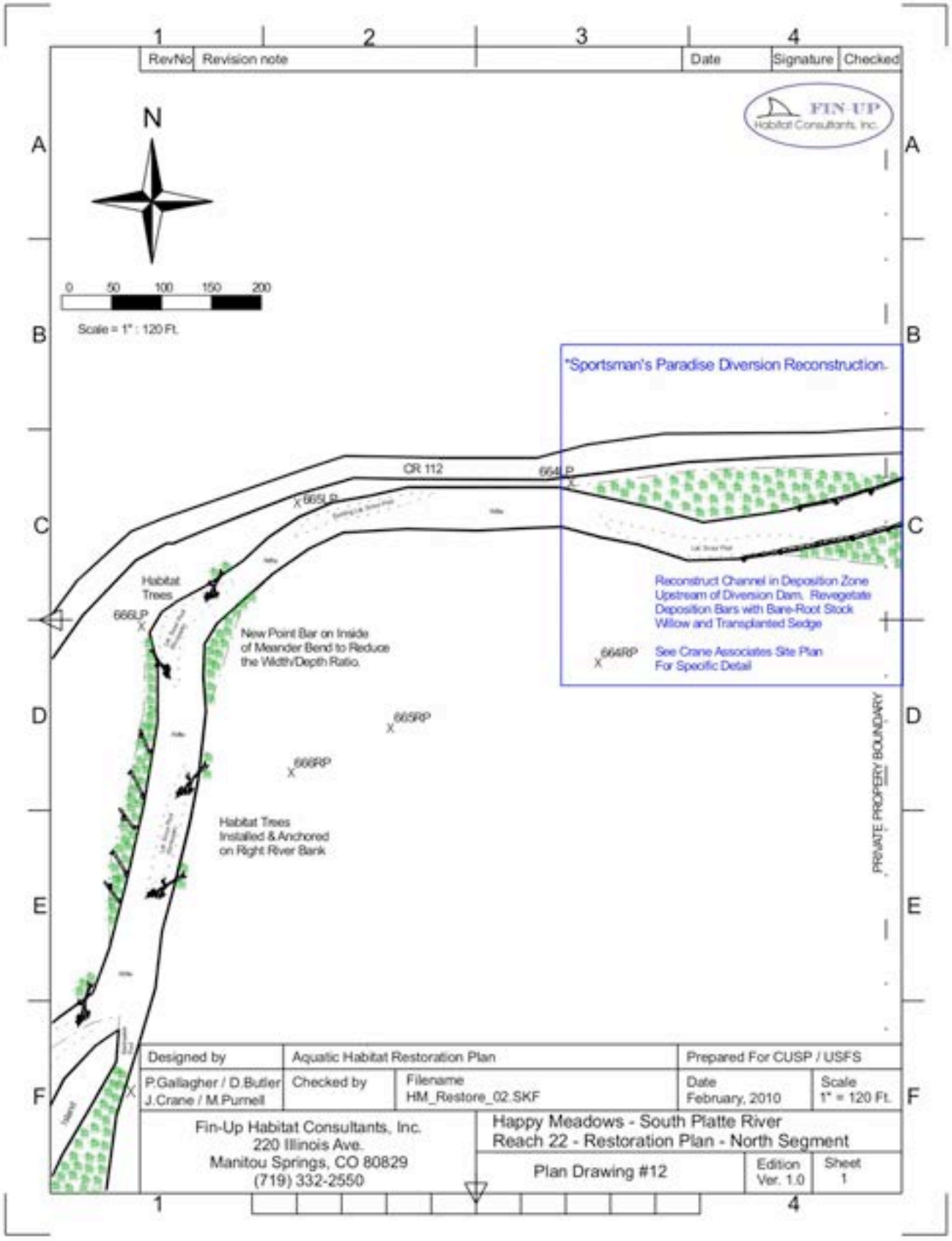
(719) 332-2550
Happy Meadows - South Platte River
Reach 22 - Restoration Plan - North Segment
Plan Drawing #1
Edition
Ver. 1.0
Sheet
1


RevNo
Revision note
Date
Signature
Checked
FIN-UP
Habitat Consultants, Inc.
N
0 50 100 150 200
Scale = 1" : 120 Ft.
"Sportsman's Paradise Diversion Reconstruction"
Reconstruct Channel in Deposition Zone Upstream of Diversion Dam. Revegetate Deposition Bars with Bare-Root Stock Willow and Transplanted Sedge
See Crane Associates Site Plan For Specific Detail
664RP
CR 112
664LP
665LP
666LP
Habitat Trees
New Point Bar on Inside of Meander Bend to Reduce the Width/Depth Ratio.
665RP
666RP
Habitat Trees Installed & Anchored on Right River Bank
PRIVATE PROPERTY BOUNDARY
Designed by
P.Gallagher / D.Butler
J.Crane / M.Purnell
Aquatic Habitat Restoration Plan
Checked by
Filename
HM_Restore_02.SKF
Prepared For CUSP / USFS
Date
February, 2010
Scale
1" = 120 Ft.
Fin-Up Habitat Consultants, Inc.
220 Illinois Ave.
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Happy Meadows - South Platte River
Reach 22 - Restoration Plan - North Segment
Plan Drawing #12
Edition
Ver. 1.0
Sheet
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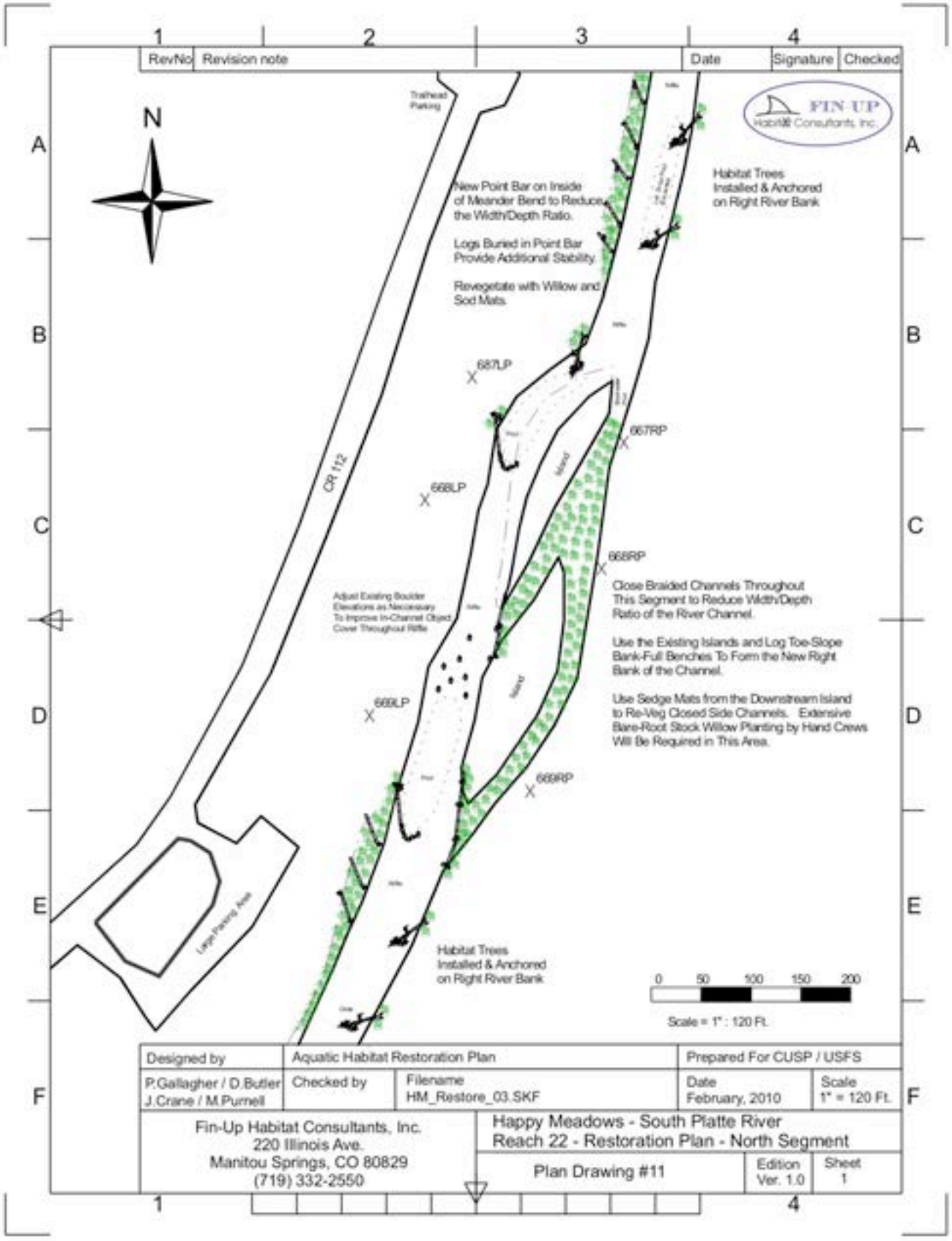
RevNo
Revision note
Date
Signature
Checked
FIN-UP
Habitat Consultants, Inc.
N
Trailhead Parking
New Point Bar on Inside of Meander Bend to Reduce the Width/Depth Ratio.
Logs Buried in Point Bar Provide Additional Stability.
Revegetate with Willow and Sod Mats.
Habitat Trees Installed & Anchored on Right River Bank
687LP
667RP
668LP
668RP
669LP
669RP
CR 112
Island
Adjust Existing Boulder Elevations as Necessary To Improve In-Channel Object Cover Throughout Riffle
Close Braided Channels Throughout This Segment to Reduce Width/Depth Ratio of the River Channel.
Use the Existing Islands and Log Toe-Slope Bank-Full Benches To Form the New Right Bank of the Channel.
Use Sedge Mats from the Downstream Island to Re-Veg Closed Side Channels. Extensive Bare-Root Stock Willow Planting by Hand Crews Will Be Required in This Area.
Large Parking Area
Habitat Trees Installed & Anchored on Right River Bank
0 50 100 150 200
Scale = 1" : 120 Ft.
Designed by
P.Gallagher / D.Butler
J.Crane / M.Purnell
Aquatic Habitat Restoration Plan
Checked by
Filename
HM_Restore_03.SKF
Prepared For CUSP / USFS
Date
February, 2010
Scale
1" = 120 Ft.
Fin-Up Habitat Consultants, Inc.
220 Illinois Ave.
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Happy Meadows - South Platte River
Reach 22 - Restoration Plan - North Segment
Plan Drawing #11
Edition
Ver. 1.0
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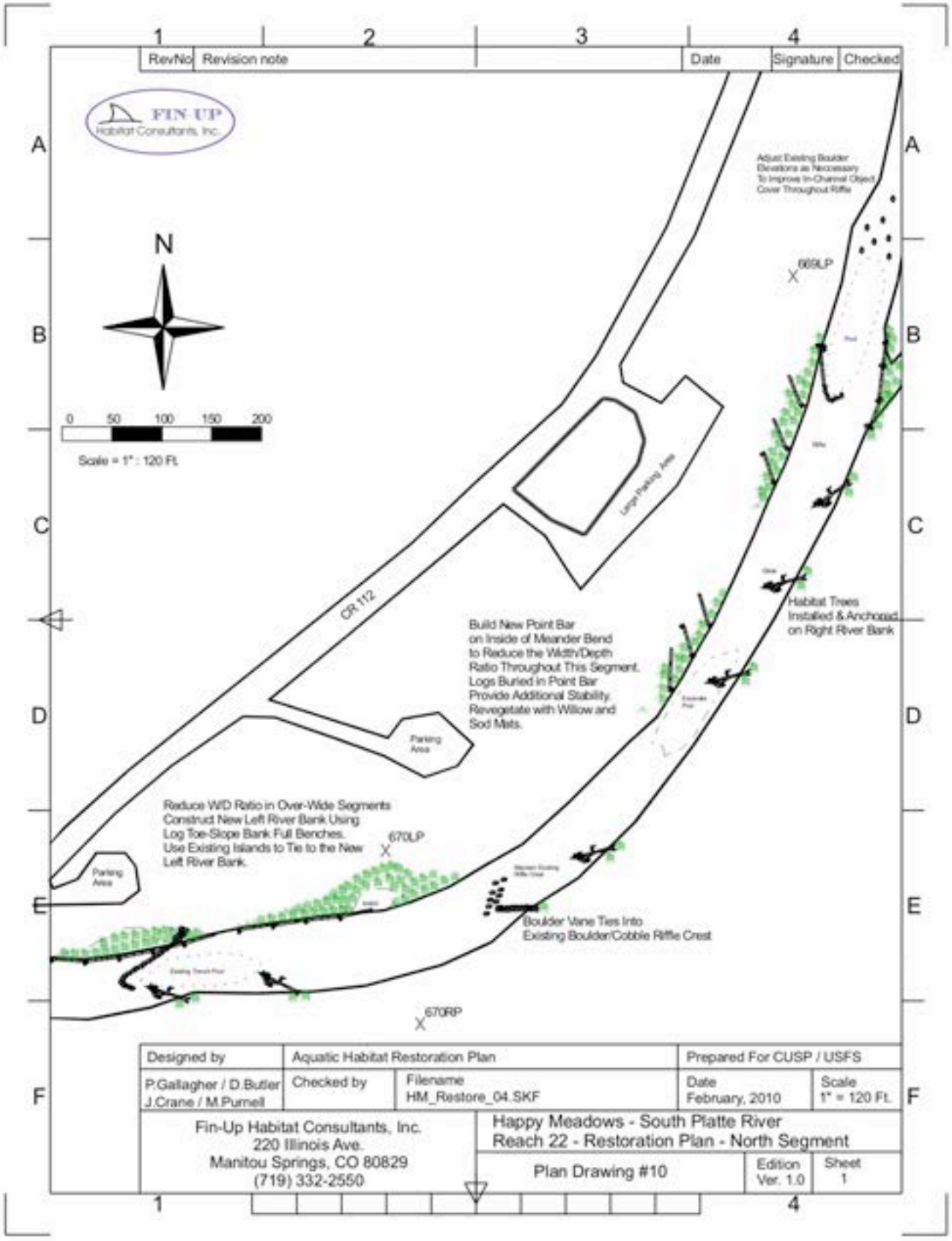
RevNo
Revision note
Date
Signature
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FIN-UP
Habitat Consultants, Inc.
N
0 50 100 150 200
Scale = 1" : 120 Ft.
Adjust Existing Boulder Elevations as Necessary To Improve In-Channel Object Cover Throughout Riffle
669LP
Large Parking Area
CR 112
Parking Area
Build New Point Bar on Inside of Meander Bend to Reduce the Width/Depth Ratio Throughout This Segment. Logs Buried in Point Bar Provide Additional Stability. Revegetate with Willow and Sod Mats.
Habitat Trees Installed & Anchored on Right River Bank
Reduce W/D Ratio in Over-Wide Segments Construct New Left River Bank Using Log Toe-Slope Bank Full Benches. Use Existing Islands to Tie to the New Left River Bank.
670LP
Parking Area
Boulder Vane Ties Into Existing Boulder/Cobble Riffle Crest
670RP
Designed by
P.Gallagher / D.Butler
J.Crane / M.Purnell
Aquatic Habitat Restoration Plan
Checked by
Filename
HM_Restore_04.SKF
Prepared For CUSP / USFS
Date
February, 2010
Scale
1" = 120 Ft.
Fin-Up Habitat Consultants, Inc.
220 Illinois Ave.
Manitou Springs, CO 80829
(719) 332-2550
Happy Meadows - South Platte River
Reach 22 - Restoration Plan - North Segment
Plan Drawing #10
Edition
Ver. 1.0
Sheet
1

APPENDIX B

PHOTO POINT INFO

Photo points are an important long-term monitoring tool. We established a photo-point series that will be remonitored in coming years.

SPORTSMANS PARADISE - POST PROJECT PHOTO POINTS METADATA FILE						
DATE: DEC 6, 2012; DEVICE: NIKON 1 V2 w/ 10-30mm Lens & GP1000 GPS Unit; MAP DATUM: WGS-84; IMAGE SIZE: 4608x3072						
File	Photo #	File Size	Focal Length	Latitude	Longitude	Photo #
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SP_XS2_014.JPG	152	8.80 MB	10mm		SP_XS2_014.JP	152
SP_XS2_015.JPG	153	8.94 MB	10mm		SP_XS2_015.JP	153
SP_XS2_016.JPG	154	9.00 MB	10mm	N 39°1.575'	SP_XS2_016.JP	154
SP_XS4_009.JPG	155	8.33 MB	30mm	N 39°1.588'	SP_XS4_009.JP	155
SP_XS4_010.JPG	156	8.95 MB	10mm	N 39°1.591'	SP_XS4_010.JP	156
SP_XS4_011.JPG	157	8.44 MB	10mm	N 39°1.587'	SP_XS4_011.JP	157
SP_XS4_012.JPG	158	8.37 MB	10mm		SP_XS4_012.JP	158
SP_XS8_005.JPG	159	8.95 MB	10mm	N 39°1.576'	SP_XS8_005.JP	159
SP_XS8_006.JPG	160	7.80 MB	10mm	N 39°1.570'	SP_XS8_006.JP	160
SP_XS8_007.JPG	161	8.75 MB	10mm	N 39°1.546'	SP_XS8_007.JP	161
SP_XS8_008.JPG	162	7.16 MB	10mm	N 39°1.565'	SP_XS8_008.JP	162
SP_XS111_045.JPG	163	7.57 MB	10mm	N 39°2.767'	SP_XS111_045.	163
SP_XS111_046.JPG	164	7.90 MB	10mm	N 39°2.771'	SP_XS111_046.	164
SP_XS111_047.JPG	165	8.08 MB	10mm	N 39°2.752'	SP_XS111_047.	165
SP_XS111_048.JPG	166	8.29 MB	10mm	N 39°2.740'	SP_XS111_048.	166
SP_XS112_049.JPG	167	8.70 MB	10mm	N 39°2.740'	SP_XS112_049.	167
SP_XS112_050.JPG	168	8.25 MB	10mm	N 39°2.746'	SP_XS112_050.	168
SP_XS112_051.JPG	169	7.29 MB	14mm	N 39°2.768'	SP_XS112_051.	169
SP_XS112_052.JPG	170	7.60 MB	14mm	N 39°2.773'	SP_XS112_052.	170

SP_Photopoint_017.JPG	123	8.46 MB	10mm	N 39°1.594'	SP_Photopoint	123
SP_Photopoint_018.JPG	124	8.52 MB	10mm	N 39°1.704'	SP_Photopoint	124
SP_Photopoint_019.JPG	125	7.71 MB	10mm	N 39°1.707'	SP_Photopoint	125
SP_Photopoint_020.JPG	126	8.39 MB	10mm	N 39°1.777'	SP_Photopoint	126
SP_Photopoint_021.JPG	127	8.46 MB	10mm	N 39°1.780'	SP_Photopoint	127
SP_Photopoint_022.JPG	128	8.30 MB	10mm	N 39°1.786'	SP_Photopoint	128
SP_Photopoint_023.JPG	129	8.64 MB	11.4mm	N 39°1.862'	SP_Photopoint	129
SP_Photopoint_024.JPG	130	8.44 MB	11.4mm	N 39°1.860'	SP_Photopoint	130
SP_Photopoint_025.JPG	131	8.35 MB	11.4mm	N 39°1.865'	SP_Photopoint	131
SP_Photopoint_026.JPG	132	8.90 MB	11mm	N 39°1.892'	SP_Photopoint	132
SP_Photopoint_027.JPG	133	8.32 MB	10mm	N 39°1.984'	SP_Photopoint	133
SP_Photopoint_028.JPG	134	8.79 MB	10mm	N 39°1.974'	SP_Photopoint	134
SP_Photopoint_029.JPG	135	8.51 MB	30mm	N 39°2.008'	SP_Photopoint	135
SP_Photopoint_030.JPG	136	8.05 MB	10mm	N 39°2.052'	SP_Photopoint	136
SP_Photopoint_031.JPG	137	8.36 MB	10mm	N 39°2.177'	SP_Photopoint	137
SP_Photopoint_032.JPG	138	8.88 MB	10mm	N 39°2.176'	SP_Photopoint	138
SP_Photopoint_033.JPG	139	8.52 MB	10mm	N 39°2.239'	SP_Photopoint	139
SP_Photopoint_034.JPG	140	8.43 MB	10mm	N 39°2.235'	SP_Photopoint	140
SP_Photopoint_035.JPG	141	7.55 MB	10mm	N 39°2.334'	SP_Photopoint	141
SP_Photopoint_036.JPG	142	8.45 MB	10mm	N 39°2.376'	SP_Photopoint	142
SP_Photopoint_037.JPG	143	8.36 MB	10mm	N 39°2.391'	SP_Photopoint	143
SP_Photopoint_038.JPG	144	8.45 MB	10mm	N 39°2.381'	SP_Photopoint	144
SP_Photopoint_039.JPG	145	8.51 MB	10mm	N 39°2.474'	SP_Photopoint	145
SP_Photopoint_040.JPG	146	8.60 MB	10mm	N 39°2.648'	SP_Photopoint	146
SP_Photopoint_041.JPG	147	8.42 MB	18.2mm	N 39°2.655'	SP_Photopoint	147
SP_Photopoint_042.JPG	148	7.91 MB	10mm	N 39°2.740'	SP_Photopoint	148
SP_Photopoint_043.JPG	149	8.48 MB	10mm	N 39°2.772'	SP_Photopoint	149
SP_Photopoint_044.JPG	150	8.19 MB	10mm	N 39°2.770'	SP_Photopoint	150

DATE: DEC 6, 2012; DEVICE: NIKON 1 V2 w/ 10-30mm Lens & GP1000 GPS Unit; MAP DATUM: WGS-84; IMAGE SIZE: 4608x3072						
File	Photo #	File Size	Focal Length	Latitude	Longitude	Altitude
HM_0002.JPG	90	8.47 MB	10mm	N 39°0.844'	W 105°21.853'	2422.00m
HM_0003.JPG	91	6.79 MB	10mm	N 39°0.830'	W 105°21.893'	2431.00m
HM_0004.JPG	92	7.91 MB	10mm	N 39°0.837'	W 105°21.834'	2414.00m
HM_0005.JPG	93	8.21 MB	21.9mm	N 39°0.794'	W 105°21.848'	2420.00m
HM_0006.JPG	94	8.36 MB	30mm	N 39°0.887'	W 105°21.721'	2421.00m
HM_0007.JPG	95	7.43 MB	10mm	N 39°0.890'	W 105°21.724'	2418.00m
HM_0008.JPG	96	7.38 MB	10mm	N 39°0.870'	W 105°21.713'	2417.00m
HM_0009.JPG	97	8.45 MB	10mm	N 39°0.882'	W 105°21.689'	2408.00m
HM_0010.JPG	98	8.61 MB	10mm	N 39°0.896'	W 105°21.687'	2423.00m
HM_0011.JPG	99	7.94 MB	10mm	N 39°1.135'	W 105°21.627'	2411.00m
HM_0012.JPG	100	8.35 MB	10mm	N 39°1.132'	W 105°21.653'	2406.00m
HM_0013.JPG	101	8.29 MB	10mm	N 39°1.135'	W 105°21.601'	2406.00m
HM_0014.JPG	102	8.29 MB	10mm	N 39°1.117'	W 105°21.621'	2401.00m
HM_0015.JPG	103	8.51 MB	10mm	N 39°1.163'	W 105°21.581'	2407.00m
HM_0016.JPG	104	8.51 MB	10mm	N 39°1.141'	W 105°21.588'	2408.00m
HM_0017.JPG	105	8.93 MB	10mm	N 39°1.141'	W 105°21.555'	2408.00m
HM_0018.JPG	106	8.07 MB	10mm	N 39°1.153'	W 105°21.550'	2408.00m
HM_0019.JPG	107	8.50 MB	10mm	N 39°1.474'	W 105°21.301'	2402.00m
HM_0020.JPG	108	8.44 MB	11.8mm	N 39°1.497'	W 105°21.279'	2384.00m
HM_0021.JPG	109	8.86 MB	11.8mm			
HM_0022.JPG	110	7.57 MB	11.8mm	N 39°1.455'	W 105°21.258'	2398.00m
HM_0023.JPG	111	8.61 MB	10mm	N 39°1.489'	W 105°21.283'	2404.00m
HM_0024.JPG	112	8.44 MB	10mm	N 39°1.472'	W 105°21.285'	2402.00m
HM_0025.JPG	113	7.28 MB	10mm			
HM_0026.JPG	114	8.62 MB	10mm	N 39°1.474'	W 105°21.256'	2410.00m
HM_0027.JPG	115	8.47 MB	10mm	N 39°1.430'	W 105°21.308'	2406.00m
HM_0028.JPG	116	7.86 MB	10mm	N 39°1.408'	W 105°21.321'	2408.00m
HM_0029.JPG	117	8.39 MB	10mm			
HM_0030.JPG	118	7.67 MB	10mm	N 39°1.422'	W 105°21.274'	2399.00m
HM_0031.JPG	119	8.68 MB	10mm	N 39°1.142'	W 105°21.613'	2411.00m
HM_0032.JPG	120	6.27 MB	10mm			
HM_0033.JPG	121	8.07 MB	10mm	N 39°1.124'	W 105°21.599'	2390.00m
HM_0034.JPG	122	7.29 MB	10mm	N 39°1.137'	W 105°21.576'	2395.00m

DATE: Sept, 2012; DEVICE: NIKON 1 V2 w/ 10-30mm Lens & GP1000 GPS Unit; MAP DATUM: WGS-84; IMAGE SIZE: 4608x3072						
File	Photo #	File Size	Latitude	Longitude	Altitude	Heading
DSC00010.JPG	10	854 KB	N 39–0.505'	W 105–21.824'	2423.84m	83
DSC00011.JPG	11	1.00 MB	N 39–0.531'	W 105–21.796'	2425.91m	85
DSC00012.JPG	12	1.00 MB	N 39–0.553'	W 105–21.818'	2424.65m	36
DSC00013.JPG	13	1.10 MB	N 39–0.556'	W 105–21.836'	2425.63m	73
DSC00014.JPG	14	1.39 MB	N 39–0.573'	W 105–21.844'	2426.03m	243
DSC00015.JPG	15	1.08 MB	N 39–0.582'	W 105–21.836'	2424.99m	120
DSC00016.JPG	16	1.01 MB	N 39–0.614'	W 105–21.843'	2424.72m	187
DSC00017.JPG	17	875 KB	N 39–0.668'	W 105–21.858'	2423.36m	93
DSC00018.JPG	18	901 KB	N 39–0.677'	W 105–21.853'	2425.69m	65
DSC00019.JPG	19	1.32 MB	N 39–0.719'	W 105–21.865'	2424.56m	342
DSC00020.JPG	20	1.31 MB	N 39–0.725'	W 105–21.883'	2424.01m	252
DSC00021.JPG	21	896 KB	N 39–0.735'	W 105–21.906'	2424.12m	212
DSC00022.JPG	22	1.11 MB	N 39–0.747'	W 105–21.916'	2424.90m	104
DSC00023.JPG	23	797 KB	N 39–0.768'	W 105–21.929'	2425.46m	218
DSC00024.JPG	24	1.16 MB	N 39–0.769'	W 105–21.928'	2424.94m	109
DSC00025.JPG	25	958 KB	N 39–0.801'	W 105–21.930'	2425.96m	136
DSC00026.JPG	26	1.15 MB	N 39–0.813'	W 105–21.926'	2425.17m	64
DSC00027.JPG	27	1.25 MB	N 39–0.820'	W 105–21.920'	2424.38m	214
DSC00028.JPG	28	973 KB	N 39–0.837'	W 105–21.888'	2429.12m	178
DSC00029.JPG	29	1.05 MB	N 39–0.854'	W 105–21.872'	2427.71m	211
DSC00030.JPG	30	1.35 MB	N 39–0.849'	W 105–21.847'	2424.40m	224
DSC00031.JPG	31	1.27 MB	N 39–0.850'	W 105–21.832'	2424.55m	333
DSC00032.JPG	32	1.24 MB	N 39–0.826'	W 105–21.810'	2423.06m	341
DSC00033.JPG	33	1.12 MB	N 39–0.807'	W 105–21.822'	2424.59m	114
DSC00034.JPG	34	962 KB	N 39–0.813'	W 105–21.770'	2423.25m	33
DSC00035.JPG	35	1.09 MB	N 39–0.813'	W 105–21.758'	2423.05m	150
DSC00036.JPG	36	0.97 MB	N 39–0.842'	W 105–21.713'	2423.60m	309
DSC00037.JPG	37	1.19 MB	N 39–0.840'	W 105–21.713'	2423.53m	61
DSC00038.JPG	38	975 KB	N 39–0.861'	W 105–21.712'	2422.51m	354
DSC00039.JPG	39	988 KB	N 39–0.876'	W 105–21.707'	2422.30m	119
DSC00040.JPG	40	1.32 MB	N 39–0.908'	W 105–21.624'	2433.08m	133
DSC00041.JPG	41	1.36 MB	N 39–0.909'	W 105–21.624'	2432.59m	9
DSC00042.JPG	42	1.21 MB	N 39–0.905'	W 105–21.640'	2430.44m	134
DSC00043.JPG	43	1.37 MB	N 39–0.906'	W 105–21.641'	2430.28m	44
DSC00044.JPG	44	1.26 MB	N 39–0.908'	W 105–21.654'	2429.29m	25
DSC00045.JPG	45	1.30 MB	N 39–0.924'	W 105–21.672'	2427.53m	20
DSC00046.JPG	46	1.06 MB	N 39–0.932'	W 105–21.686'	2424.48m	318
DSC00047.JPG	47	1.22 MB	N 39–0.934'	W 105–21.686'	2424.85m	53
DSC00048.JPG	48	1.28 MB	N 39–0.954'	W 105–21.694'	2423.60m	278
DSC00049.JPG	49	1.14 MB	N 39–0.959'	W 105–21.705'	2423.89m	353

APPENDIX C

HEC RAS

This pre-project Hec Ras data will be compared to a model run in 2014 or 2015.

HEC-RAS Plan: Plan 01 River: South Platte Reach: Happy Meadows

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Happy Meadows	699	error	32.00	7864.61	7866.99		7867.01	0.000809	1.28	24.98	19.48	0.20
Happy Meadows	699	1-yr	160.00	7864.61	7867.97		7868.12	0.003884	3.13	51.10	34.22	0.45
Happy Meadows	699	2-yr	426.00	7864.61	7868.99		7869.34	0.005220	4.79	89.42	39.20	0.56
Happy Meadows	699	5 yr	880.00	7864.61	7869.61		7870.12	0.005724	5.79	119.51	74.18	0.60
Happy Meadows	699	10-yr	846.00	7864.61	7869.84	7869.14	7870.52	0.007063	6.69	139.70	119.67	0.67
Happy Meadows	699	50 yr	1351.00	7864.61	7870.75		7871.12	0.003789	5.80	382.19	312.19	0.51
Happy Meadows	699	100 yr	1613.00	7864.61	7871.08		7871.38	0.003083	5.51	488.01	325.47	0.47
Happy Meadows	699	500 yr	2336.00	7864.61	7871.82		7872.08	0.002208	5.20	739.57	393.20	0.41
Happy Meadows	698	error	32.00	7865.01	7866.91		7866.90	0.000739	0.54	59.62	70.82	0.13
Happy Meadows	698	1-yr	160.00	7865.01	7867.74		7867.77	0.000770	1.25	127.55	98.22	0.19
Happy Meadows	698	2-yr	426.00	7865.01	7868.86		7868.91	0.000726	1.69	252.89	127.69	0.21
Happy Meadows	698	5 yr	880.00	7865.01	7869.61		7869.65	0.000659	1.81	397.88	245.81	0.20
Happy Meadows	698	10-yr	846.00	7865.01	7869.93		7869.99	0.000670	1.98	478.87	250.86	0.21
Happy Meadows	698	50 yr	1351.00	7865.01	7870.66		7870.73	0.000685	2.33	665.42	284.33	0.22
Happy Meadows	698	100 yr	1613.00	7865.01	7870.94		7871.03	0.000723	2.52	741.48	279.55	0.23
Happy Meadows	698	500 yr	2336.00	7865.01	7871.64		7871.75	0.000782	2.95	944.83	313.88	0.24
Happy Meadows	697	error	32.00	7865.53	7866.90	7866.44	7866.91	0.001507	0.89	36.97	79.23	0.23
Happy Meadows	697	1-yr	160.00	7865.53	7867.72		7867.75	0.001150	1.47	108.71	90.72	0.24
Happy Meadows	697	2-yr	426.00	7865.53	7868.83		7868.89	0.000982	1.98	220.03	150.62	0.24
Happy Meadows	697	5 yr	880.00	7865.53	7869.58		7869.64	0.001006	1.93	380.34	258.17	0.24
Happy Meadows	697	10-yr	846.00	7865.53	7869.92		7869.98	0.000915	2.04	466.93	267.24	0.24
Happy Meadows	697	50 yr	1351.00	7865.53	7870.65		7870.72	0.000813	2.31	669.78	288.48	0.23
Happy Meadows	697	100 yr	1613.00	7865.53	7870.93		7871.01	0.000804	2.47	752.45	296.80	0.24
Happy Meadows	697	500 yr	2336.00	7865.53	7871.63		7871.73	0.000843	2.83	972.91	332.44	0.25
Happy Meadows	696	error	32.00	7862.90	7863.78	7863.78	7864.07	0.026666	4.28	7.47	13.30	1.01
Happy Meadows	696	1-yr	160.00	7862.90	7864.84	7864.84	7865.53	0.021084	6.64	24.11	17.83	1.01
Happy Meadows	696	2 yr	426.00	7862.90	7866.19	7866.19	7866.84	0.020280	6.93	61.47	42.33	1.01
Happy Meadows	696	5 yr	880.00	7862.90	7866.70	7866.70	7867.66	0.018509	7.86	84.29	46.68	1.01
Happy Meadows	696	10-yr	846.00	7862.90	7867.08	7867.08	7868.16	0.018303	8.35	103.11	52.52	0.98
Happy Meadows	696	50 yr	1351.00	7862.90	7868.15	7868.15	7869.21	0.010162	8.52	182.37	107.76	0.82
Happy Meadows	696	100 yr	1613.00	7862.90	7868.64	7868.64	7869.58	0.007955	8.28	249.48	157.85	0.75
Happy Meadows	696	500 yr	2336.00	7862.90	7869.27	7869.27	7870.28	0.007710	9.01	355.90	177.59	0.75
Happy Meadows	695	error	32.00	7861.34	7863.04	7862.19	7863.06	0.000671	0.78	41.00	53.31	0.18
Happy Meadows	695	1-yr	160.00	7861.34	7864.08		7864.10	0.000855	1.50	106.99	70.37	0.21
Happy Meadows	695	2-yr	426.00	7861.34	7864.97		7865.08	0.001296	2.47	173.59	77.52	0.28
Happy Meadows	695	5 yr	880.00	7861.34	7865.53		7865.65	0.001565	3.11	218.45	85.37	0.32
Happy Meadows	695	10-yr	846.00	7861.34	7865.90		7866.06	0.001940	3.47	253.15	94.93	0.34
Happy Meadows	695	50-yr	1351.00	7861.34	7866.76		7867.04	0.001827	4.27	341.22	110.29	0.37
Happy Meadows	695	100 yr	1613.00	7861.34	7867.08		7867.40	0.001978	4.67	377.33	115.98	0.38
Happy Meadows	695	500 yr	2335.00	7861.34	7867.76		7868.23	0.002459	5.71	459.57	128.08	0.44
Happy Meadows	694	error	32.00	7861.26	7861.72	7861.72	7861.89	0.030206	3.26	9.81	29.49	1.00
Happy Meadows	694	1-yr	160.00	7861.26	7862.20	7862.20	7862.47	0.027166	4.22	37.90	71.40	1.02
Happy Meadows	694	2 yr	426.00	7861.26	7863.03		7863.31	0.008316	4.24	100.40	76.59	0.66
Happy Meadows	694	5 yr	880.00	7861.26	7863.84		7864.09	0.004349	4.05	183.73	81.34	0.49
Happy Meadows	694	10-yr	846.00	7861.26	7864.13		7864.45	0.004304	4.55	189.33	98.93	0.52
Happy Meadows	694	50 yr	1351.00	7861.26	7864.76		7865.22	0.004952	5.54	278.94	208.28	0.58
Happy Meadows	694	100 yr	1613.00	7861.26	7865.07		7865.51	0.004806	5.82	334.41	271.99	0.57
Happy Meadows	694	500 yr	2336.00	7861.26	7865.67		7866.18	0.004153	6.23	488.49	349.15	0.55
Happy Meadows	693	error	32.00	7858.31	7860.39		7860.40	0.000181	0.61	52.17	41.14	0.13
Happy Meadows	693	1-yr	160.00	7858.31	7861.31		7861.38	0.000872	1.71	93.81	51.33	0.27
Happy Meadows	693	2-yr	426.00	7858.31	7862.17		7862.31	0.001892	3.04	139.94	56.01	0.34
Happy Meadows	693	5 yr	880.00	7858.31	7862.82		7863.00	0.003731	3.41	194.01	114.43	0.45
Happy Meadows	693	10-yr	846.00	7858.31	7863.15		7863.36	0.003440	3.68	232.27	118.10	0.45
Happy Meadows	693	50 yr	1351.00	7858.31	7863.95		7864.20	0.002731	4.07	368.86	220.18	0.42
Happy Meadows	693	100 yr	1613.00	7858.31	7864.27		7864.53	0.003528	4.20	440.85	229.98	0.47
Happy Meadows	693	500 yr	2336.00	7858.31	7865.01		7865.30	0.002265	4.57	621.68	268.26	0.41
Happy Meadows	692	error	32.00	7858.99	7860.14	7860.14	7860.29	0.038731	3.17	10.09	36.29	1.06
Happy Meadows	692	1-yr	160.00	7858.99	7861.04		7861.12	0.004057	2.22	72.25	85.34	0.42
Happy Meadows	692	2-yr	426.00	7858.99	7861.81		7861.95	0.003458	2.99	143.60	98.32	0.43
Happy Meadows	692	5 yr	880.00	7858.99	7862.52		7862.50	0.003195	3.43	196.40	110.89	0.43
Happy Meadows	692	10-yr	846.00	7858.99	7862.70		7862.91	0.002940	3.64	241.70	128.12	0.42
Happy Meadows	692	50 yr	1351.00	7858.99	7863.60		7863.84	0.002268	4.03	388.16	232.93	0.39
Happy Meadows	692	100 yr	1613.00	7858.99	7863.95		7864.19	0.002040	4.10	473.53	242.89	0.38
Happy Meadows	692	500 yr	2336.00	7858.99	7864.76		7865.00	0.001778	4.37	678.94	276.13	0.37
Happy Meadows	691	error	32.00	7858.20	7859.92		7859.94	0.000943	1.01	31.74	40.94	0.20
Happy Meadows	691	1-yr	160.00	7858.20	7860.89		7860.94	0.001653	1.85	86.18	67.40	0.29
Happy Meadows	691	2 yr	426.00	7858.20	7861.58		7861.73	0.002947	3.21	132.91	68.72	0.41

HEC-RAS Plan: Plan 01 River: South Platte Reach: Happy Meadows (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Happy Meadows	691	5 yr	660.00	7858.20	7862.01		7862.27	0.003477	4.06	163.25	70.46	0.46
Happy Meadows	691	10-yr	846.00	7858.20	7862.36		7862.68	0.003619	4.53	187.97	72.55	0.48
Happy Meadows	691	50-yr	1351.00	7858.20	7863.29		7863.63	0.003632	5.35	280.78	150.91	0.50
Happy Meadows	691	100 yr	1610.00	7858.20	7863.53		7863.89	0.003489	5.65	338.24	182.94	0.50
Happy Meadows	691	500-yr	2335.00	7858.20	7864.34		7864.82	0.003137	6.04	515.53	264.55	0.49
Happy Meadows	690	error	32.00	7858.25	7858.97	7858.97	7859.10	0.037347	2.94	10.88	43.97	1.04
Happy Meadows	690	1-yr	160.00	7858.25	7859.40	7859.40	7859.65	0.039527	4.07	39.35	79.42	1.02
Happy Meadows	690	2-yr	426.00	7858.25	7860.24		7860.48	0.007204	3.73	114.30	91.91	0.58
Happy Meadows	690	5 yr	660.00	7858.25	7861.00		7861.20	0.003835	3.56	185.73	94.99	0.45
Happy Meadows	690	10-yr	846.00	7858.25	7861.50		7861.71	0.002813	3.64	232.92	97.44	0.41
Happy Meadows	690	50-yr	1351.00	7858.25	7862.58		7862.80	0.002031	3.93	378.20	188.47	0.37
Happy Meadows	690	100 yr	1610.00	7858.25	7862.94		7863.19	0.001903	4.08	450.11	199.69	0.36
Happy Meadows	690	500-yr	2335.00	7858.25	7863.83		7864.10	0.001701	4.42	647.84	248.15	0.36
Happy Meadows	689.7	error	32.00	7855.89	7857.48		7857.50	0.001349	1.00	32.00	94.14	0.23
Happy Meadows	689.7	1-yr	160.00	7855.89	7858.52		7858.56	0.001202	1.57	102.48	78.62	0.24
Happy Meadows	689.7	2-yr	426.00	7855.89	7859.84		7859.90	0.000791	2.07	210.05	92.08	0.24
Happy Meadows	689.7	5 yr	660.00	7855.89	7860.70		7860.77	0.000688	2.18	317.75	149.57	0.25
Happy Meadows	689.7	10-yr	846.00	7855.89	7861.26		7861.33	0.000628	2.21	402.19	164.69	0.23
Happy Meadows	689.7	50-yr	1351.00	7855.89	7862.38		7862.47	0.000579	2.47	605.37	200.79	0.22
Happy Meadows	689.7	100 yr	1610.00	7855.89	7862.78		7862.88	0.000600	2.64	683.32	211.60	0.22
Happy Meadows	689.7	500-yr	2335.00	7855.89	7863.84		7863.77	0.000859	3.08	882.66	241.02	0.25
Happy Meadows	689	error	32.00	7854.98	7856.81		7856.84	0.001874	1.43	22.39	28.50	0.28
Happy Meadows	689	1-yr	160.00	7854.98	7858.04		7858.09	0.001288	1.73	92.33	66.19	0.26
Happy Meadows	689	2-yr	426.00	7854.98	7859.47		7859.55	0.000885	2.24	190.99	72.88	0.24
Happy Meadows	689	5 yr	660.00	7854.98	7860.35		7860.45	0.000827	2.61	259.81	85.18	0.24
Happy Meadows	689	10-yr	846.00	7854.98	7860.90		7861.03	0.000825	2.88	309.71	94.88	0.25
Happy Meadows	689	50-yr	1351.00	7854.98	7861.98		7862.17	0.000911	3.51	423.64	117.07	0.27
Happy Meadows	689	100 yr	1610.00	7854.98	7862.31		7862.53	0.001002	3.89	462.97	124.80	0.29
Happy Meadows	689	500-yr	2335.00	7854.98	7863.05		7863.38	0.001342	4.81	561.51	142.08	0.34
Happy Meadows	688	error	32.00	7854.14	7856.82		7856.82	0.000014	0.21	149.89	81.19	0.03
Happy Meadows	688	1-yr	160.00	7854.14	7858.04		7858.04	0.000064	0.64	253.33	90.52	0.06
Happy Meadows	688	2-yr	426.00	7854.14	7859.47		7859.48	0.000119	1.13	403.04	142.87	0.09
Happy Meadows	688	5 yr	660.00	7854.14	7860.35		7860.36	0.000141	1.38	542.44	169.41	0.11
Happy Meadows	688	10-yr	846.00	7854.14	7860.91		7860.94	0.000154	1.54	640.93	183.81	0.11
Happy Meadows	688	50-yr	1351.00	7854.14	7862.01		7862.06	0.000191	1.93	849.83	200.16	0.13
Happy Meadows	688	100 yr	1610.00	7854.14	7862.34		7862.40	0.000222	2.15	917.59	205.65	0.14
Happy Meadows	688	500-yr	2335.00	7854.14	7863.19		7863.19	0.000307	2.70	1081.84	223.30	0.17
Happy Meadows	687	error	32.00	7854.80	7856.82		7856.82	0.000058	0.33	96.64	79.22	0.05
Happy Meadows	687	1-yr	160.00	7854.80	7858.02		7858.03	0.000143	0.83	193.89	83.08	0.09
Happy Meadows	687	2-yr	426.00	7854.80	7859.43		7859.46	0.000210	1.37	319.81	86.19	0.12
Happy Meadows	687	5 yr	660.00	7854.80	7860.31		7860.35	0.000245	1.69	415.94	135.30	0.14
Happy Meadows	687	10-yr	846.00	7854.80	7860.88		7860.92	0.000264	1.89	494.58	147.76	0.15
Happy Meadows	687	50-yr	1351.00	7854.80	7861.94		7862.02	0.000320	2.38	665.01	168.39	0.17
Happy Meadows	687	100 yr	1610.00	7854.80	7862.26		7862.36	0.000372	2.83	720.12	174.64	0.18
Happy Meadows	687	500-yr	2335.00	7854.80	7862.99		7863.14	0.000513	3.31	852.24	188.78	0.21
Happy Meadows	686	error	32.00	7855.41	7856.73		7856.79	0.003331	1.94	16.53	20.48	0.38
Happy Meadows	686	1-yr	160.00	7855.41	7857.70		7857.96	0.008308	3.98	40.19	28.99	0.68
Happy Meadows	686	2-yr	426.00	7855.41	7858.78		7859.33	0.007449	5.97	72.72	35.97	0.68
Happy Meadows	686	5 yr	660.00	7855.41	7859.40		7860.19	0.007965	7.19	98.36	48.62	0.73
Happy Meadows	686	10-yr	846.00	7855.41	7859.74	7859.45	7860.72	0.008892	8.15	114.88	53.18	0.78
Happy Meadows	686	50-yr	1351.00	7855.41	7860.91	7860.91	7861.83	0.008328	8.38	223.21	140.18	0.89
Happy Meadows	686	100 yr	1610.00	7855.41	7861.20	7861.20	7862.15	0.008347	8.75	285.72	148.10	0.70
Happy Meadows	686	500-yr	2335.00	7855.41	7861.82	7861.82	7862.89	0.006703	9.75	383.22	164.64	0.74
Happy Meadows	685	error	32.00	7854.75	7856.27		7856.28	0.001304	0.97	33.04	57.81	0.23
Happy Meadows	685	1-yr	160.00	7854.75	7857.33		7857.37	0.001212	1.68	95.62	69.57	0.25
Happy Meadows	685	2-yr	426.00	7854.75	7858.50		7858.60	0.001154	2.58	168.72	79.14	0.27
Happy Meadows	685	5 yr	660.00	7854.75	7859.21		7859.36	0.001238	3.09	231.65	127.64	0.29
Happy Meadows	685	10-yr	846.00	7854.75	7859.65		7859.81	0.001259	3.37	297.42	169.72	0.30
Happy Meadows	685	50-yr	1351.00	7854.75	7860.52		7860.71	0.001225	3.80	471.05	213.65	0.31
Happy Meadows	685	100 yr	1610.00	7854.75	7860.89		7861.08	0.001199	3.95	548.79	216.37	0.31
Happy Meadows	685	500-yr	2335.00	7854.75	7861.74		7861.96	0.001173	4.32	737.94	233.44	0.31
Happy Meadows	684.8	error	32.00	7852.95	7853.93		7854.02	0.006504	2.37	13.52	20.61	0.52
Happy Meadows	684.8	1-yr	160.00	7852.95	7855.18	7854.51	7855.37	0.007778	3.52	45.42	42.63	0.60
Happy Meadows	684.8	2-yr	426.00	7852.95	7855.98	7855.61	7856.31	0.008949	4.61	92.42	83.38	0.61
Happy Meadows	684.8	5 yr	660.00	7852.95	7856.58	7856.01	7856.86	0.010007	5.58	118.12	79.05	0.73
Happy Meadows	684.8	10-yr	846.00	7852.95	7856.65	7856.30	7857.24	0.010491	6.18	139.06	73.81	0.76
Happy Meadows	684.8	50-yr	1351.00	7852.95	7857.38	7856.99	7858.13	0.011359	7.10	195.11	89.19	0.81

HEC-RAS Plan: Plan 01 River: South Platte Reach: Happy Meadows (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Happy Meadows	684.8	100-yr	1810.00	7852.95	7857.63	7857.32	7858.50	0.011733	7.57	220.78	101.21	0.84
Happy Meadows	684.8	500-yr	2335.00	7852.95	7858.17	7858.09	7859.34	0.012672	8.83	278.85	109.72	0.90
Happy Meadows	684	min	32.00	7844.82	7845.88	7845.88	7846.00	0.030000	3.07	10.38	35.32	0.97
Happy Meadows	684	1-yr	160.00	7844.82	7846.32	7846.32	7846.60	0.027369	4.24	37.78	70.87	1.02
Happy Meadows	684	2-yr	426.00	7844.82	7846.81	7846.81	7847.29	0.023127	5.55	76.79	84.60	1.03
Happy Meadows	684	5-yr	660.00	7844.82	7847.14	7847.14	7847.76	0.020018	6.29	104.94	85.68	1.00
Happy Meadows	684	10-yr	848.00	7844.82	7847.37	7847.37	7848.09	0.018978	6.81	124.26	86.37	1.00
Happy Meadows	684	50-yr	1351.00	7844.82	7847.88	7847.88	7848.87	0.017474	7.98	169.41	87.85	1.01
Happy Meadows	684	100-yr	1810.00	7844.82	7848.12	7848.12	7849.24	0.016869	8.47	190.49	88.71	1.01
Happy Meadows	684	500-yr	2335.00	7844.82	7848.79	7848.79	7850.16	0.015145	9.51	247.30	90.99	1.00
Happy Meadows	683	min	32.00	7835.71	7838.71		7838.72	0.000219	0.71	44.82	31.55	0.11
Happy Meadows	683	1-yr	160.00	7835.71	7840.06		7840.10	0.000582	1.55	103.39	47.85	0.19
Happy Meadows	683	2-yr	426.00	7835.71	7841.43		7841.53	0.000824	2.51	171.89	54.78	0.24
Happy Meadows	683	5-yr	660.00	7835.71	7842.28		7842.43	0.000941	3.09	225.68	84.87	0.26
Happy Meadows	683	10-yr	848.00	7835.71	7842.84		7843.02	0.000967	3.40	278.44	99.55	0.27
Happy Meadows	683	50-yr	1351.00	7835.71	7844.15		7844.36	0.000947	3.93	431.29	152.97	0.28
Happy Meadows	683	100-yr	1810.00	7835.71	7844.81		7844.83	0.000868	4.15	503.60	162.48	0.28
Happy Meadows	683	500-yr	2335.00	7835.71	7845.37		7845.67	0.001183	4.95	632.47	175.09	0.32
Happy Meadows	682	min	32.00	7837.51	7838.27	7838.27	7838.47	0.029377	3.62	8.83	22.06	1.01
Happy Meadows	682	1-yr	160.00	7837.51	7839.01	7839.01	7839.51	0.027339	5.69	28.12	28.96	1.02
Happy Meadows	682	2-yr	426.00	7837.51	7839.95	7839.95	7840.76	0.018518	7.22	59.01	36.85	1.01
Happy Meadows	682	5-yr	660.00	7837.51	7840.51	7840.51	7841.51	0.017366	8.28	79.94	38.12	1.00
Happy Meadows	682	10-yr	848.00	7837.51	7840.90	7840.90	7842.13	0.016801	8.93	96.75	38.88	1.01
Happy Meadows	682	50-yr	1351.00	7837.51	7841.80	7841.80	7843.46	0.016965	10.37	131.70	44.85	1.00
Happy Meadows	682	100-yr	1810.00	7837.51	7842.53	7842.53	7844.01	0.016392	9.88	179.58	97.83	0.86
Happy Meadows	682	500-yr	2335.00	7837.51	7843.70	7843.70	7844.86	0.009740	9.41	334.14	153.96	0.72
Happy Meadows	681	min	32.00	7836.81	7837.43		7837.44	0.000272	0.67	47.45	43.92	0.11
Happy Meadows	681	1-yr	160.00	7836.81	7838.38		7838.43	0.000909	1.75	91.62	49.80	0.23
Happy Meadows	681	2-yr	426.00	7836.81	7839.28		7839.43	0.001754	3.11	137.19	51.25	0.33
Happy Meadows	681	5-yr	660.00	7836.81	7839.86		7840.10	0.002188	3.95	168.47	56.53	0.38
Happy Meadows	681	10-yr	848.00	7836.81	7840.25		7840.57	0.002449	4.51	192.10	68.76	0.41
Happy Meadows	681	50-yr	1351.00	7836.81	7841.19		7841.63	0.002939	5.44	283.62	113.27	0.45
Happy Meadows	681	100-yr	1810.00	7836.81	7841.59		7842.06	0.002909	5.76	331.22	126.66	0.45
Happy Meadows	681	500-yr	2335.00	7836.81	7842.59		7843.12	0.002481	6.30	482.09	173.10	0.45
Happy Meadows	680	min	32.00	7836.99	7837.39		7837.41	0.001868	1.16	27.76	44.91	0.28
Happy Meadows	680	1-yr	160.00	7836.99	7838.28		7838.35	0.002027	2.10	76.12	57.68	0.37
Happy Meadows	680	2-yr	426.00	7836.99	7839.13		7839.31	0.002814	3.35	137.86	63.38	0.41
Happy Meadows	680	5-yr	660.00	7836.99	7839.71		7839.96	0.002994	4.05	166.08	66.93	0.44
Happy Meadows	680	10-yr	848.00	7836.99	7840.11		7840.42	0.003091	4.49	192.77	73.85	0.45
Happy Meadows	680	50-yr	1351.00	7836.99	7841.04		7841.47	0.003328	5.34	276.53	104.67	0.47
Happy Meadows	680	100-yr	1810.00	7836.99	7841.44		7841.91	0.003308	5.67	320.90	120.51	0.48
Happy Meadows	680	500-yr	2335.00	7836.99	7842.48		7842.98	0.002982	6.15	464.26	156.69	0.47
Happy Meadows	679	min	32.00	7836.01	7836.77	7836.72	7836.95	0.020882	3.34	9.59	20.66	0.87
Happy Meadows	679	1-yr	160.00	7836.01	7837.96		7838.02	0.004775	2.11	75.80	109.68	0.45
Happy Meadows	679	2-yr	426.00	7836.01	7838.97		7839.04	0.001847	2.20	193.84	119.09	0.30
Happy Meadows	679	5-yr	660.00	7836.01	7839.61		7839.71	0.001305	2.44	271.57	121.91	0.28
Happy Meadows	679	10-yr	848.00	7836.01	7840.05		7840.16	0.001193	2.62	325.04	123.33	0.28
Happy Meadows	679	50-yr	1351.00	7836.01	7841.09		7841.20	0.001068	3.04	451.09	128.23	0.28
Happy Meadows	679	100-yr	1810.00	7836.01	7841.47		7841.63	0.001063	3.28	565.58	138.09	0.28
Happy Meadows	679	500-yr	2335.00	7836.01	7842.50		7842.71	0.001027	3.73	805.97	155.75	0.29
Happy Meadows	678	min	32.00	7834.59	7836.58		7836.59	0.000521	0.81	39.41	45.07	0.15
Happy Meadows	678	1-yr	160.00	7834.59	7837.68		7837.83	0.001081	1.74	91.83	57.82	0.24
Happy Meadows	678	2-yr	426.00	7834.59	7838.61		7838.75	0.001491	2.77	157.16	79.83	0.31
Happy Meadows	678	5-yr	660.00	7834.59	7839.25		7839.42	0.001573	3.31	217.95	104.35	0.33
Happy Meadows	678	10-yr	848.00	7834.59	7839.69		7839.85	0.001557	3.59	264.91	109.33	0.33
Happy Meadows	678	50-yr	1351.00	7834.59	7840.69		7840.84	0.001535	4.20	385.04	137.72	0.34
Happy Meadows	678	100-yr	1810.00	7834.59	7841.11		7841.27	0.001508	4.61	443.77	143.81	0.35
Happy Meadows	678	500-yr	2335.00	7834.59	7842.16		7842.46	0.001435	4.87	607.69	169.39	0.36
Happy Meadows	677	min	32.00	7834.59	7836.51		7836.52	0.000807	0.80	40.17	53.06	0.16
Happy Meadows	677	1-yr	160.00	7834.59	7837.48		7837.50	0.001094	1.69	94.76	80.03	0.24
Happy Meadows	677	2-yr	426.00	7834.59	7838.44		7838.55	0.001462	2.74	156.85	84.87	0.30
Happy Meadows	677	5-yr	660.00	7834.59	7839.04		7839.22	0.001894	3.41	198.89	72.28	0.34
Happy Meadows	677	10-yr	848.00	7834.59	7839.45		7839.68	0.001825	3.84	229.17	76.92	0.36
Happy Meadows	677	50-yr	1351.00	7834.59	7840.38		7840.72	0.002053	4.76	321.57	145.35	0.40
Happy Meadows	677	100-yr	1810.00	7834.59	7840.81		7841.16	0.001975	4.96	387.71	159.11	0.39
Happy Meadows	677	500-yr	2335.00	7834.59	7841.90		7842.28	0.001991	5.21	577.31	185.60	0.37

HEC-RAS Plan: Plan 01 River: South Platte Reach: Happy Meadows (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Happy Meadows	678	min	32.00	7835.19	7835.94	7835.94	7836.22	0.029590	4.23	7.57	15.04	1.06
Happy Meadows	678	1-yr	160.00	7835.19	7836.79		7837.09	0.016850	4.36	36.71	45.80	0.88
Happy Meadows	678	2-yr	426.00	7835.19	7837.61		7838.05	0.012064	5.33	79.93	57.24	0.79
Happy Meadows	678	5 yr	660.00	7835.19	7838.08		7838.67	0.011257	6.12	107.86	60.28	0.80
Happy Meadows	678	10-yr	846.00	7835.19	7838.39		7839.09	0.011016	6.69	126.82	62.17	0.81
Happy Meadows	678	50-yr	1351.00	7835.19	7839.08		7840.07	0.011050	8.01	170.44	65.29	0.85
Happy Meadows	678	100 yr	1610.00	7835.19	7839.37	7839.11	7840.51	0.011179	8.61	189.59	66.48	0.87
Happy Meadows	678	500-yr	2335.00	7835.19	7839.93	7839.91	7841.82	0.013248	10.49	227.38	68.53	0.97
Happy Meadows	675	min	32.00	7834.60	7835.79		7836.80	0.030952	0.96	33.59	48.91	0.20
Happy Meadows	675	1-yr	160.00	7834.60	7836.48		7836.57	0.002803	2.29	70.00	59.66	0.36
Happy Meadows	675	2-yr	426.00	7834.60	7837.19		7837.41	0.004270	3.82	111.62	60.14	0.49
Happy Meadows	675	5 yr	660.00	7834.60	7837.80		7837.98	0.005324	4.83	136.83	61.82	0.57
Happy Meadows	675	10-yr	846.00	7834.60	7837.87		7838.30	0.005969	5.53	153.59	64.11	0.61
Happy Meadows	675	50-yr	1351.00	7834.60	7838.48		7839.24	0.007524	7.12	194.27	76.18	0.71
Happy Meadows	675	100 yr	1610.00	7834.60	7838.70	7838.16	7839.64	0.008178	7.81	214.37	91.21	0.75
Happy Meadows	675	500-yr	2335.00	7834.60	7839.38	7839.33	7840.57	0.008658	9.06	296.38	149.44	0.80
Happy Meadows	674	min	32.00	7834.79	7835.67		7835.85	0.005112	1.32	24.19	74.12	0.41
Happy Meadows	674	1-yr	160.00	7834.79	7836.22		7836.30	0.003948	2.18	73.39	87.43	0.42
Happy Meadows	674	2-yr	426.00	7834.79	7836.88		7837.04	0.004192	3.22	132.48	91.70	0.47
Happy Meadows	674	5 yr	660.00	7834.79	7837.29		7837.52	0.004494	3.89	169.56	92.57	0.51
Happy Meadows	674	10-yr	846.00	7834.79	7837.56		7837.85	0.004663	4.33	195.29	93.18	0.53
Happy Meadows	674	50-yr	1351.00	7834.79	7838.19		7838.63	0.004957	5.31	254.75	95.08	0.57
Happy Meadows	674	100 yr	1610.00	7834.79	7838.48		7838.99	0.005080	5.73	281.77	96.09	0.58
Happy Meadows	674	500-yr	2335.00	7834.79	7839.17		7839.87	0.005272	6.72	356.96	129.03	0.62
Happy Meadows	673	min	32.00	7833.02	7833.79		7833.84	0.008770	1.84	17.35	48.39	0.54
Happy Meadows	673	1-yr	160.00	7833.02	7834.31		7834.48	0.013188	3.29	48.62	77.20	0.73
Happy Meadows	673	2-yr	426.00	7833.02	7834.85		7835.17	0.012618	4.60	92.63	85.79	0.78
Happy Meadows	673	5 yr	660.00	7833.02	7835.24		7835.66	0.012983	5.19	127.07	88.22	0.76
Happy Meadows	673	10-yr	846.00	7833.02	7835.51		7836.00	0.013023	5.60	151.25	90.29	0.78
Happy Meadows	673	50-yr	1351.00	7833.02	7836.12		7836.79	0.009419	6.56	208.45	101.90	0.76
Happy Meadows	673	100 yr	1610.00	7833.02	7836.39		7837.13	0.009157	6.96	236.34	105.94	0.77
Happy Meadows	673	500-yr	2335.00	7833.02	7837.09		7838.00	0.008733	7.91	339.27	123.23	0.78
Happy Meadows	672	min	32.00	7832.10	7833.00	7832.88	7833.09	0.013469	1.89	16.95	52.11	0.58
Happy Meadows	672	1-yr	160.00	7832.10	7833.60	7833.32	7833.71	0.006754	2.62	61.02	82.40	0.54
Happy Meadows	672	2-yr	426.00	7832.10	7834.35		7834.54	0.004791	3.44	124.03	86.88	0.50
Happy Meadows	672	5 yr	660.00	7832.10	7834.78		7835.04	0.004797	4.11	162.65	93.89	0.53
Happy Meadows	672	10-yr	846.00	7832.10	7835.07		7835.38	0.004815	4.54	190.42	97.39	0.54
Happy Meadows	672	50-yr	1351.00	7832.10	7835.71		7836.17	0.005076	5.53	254.98	107.56	0.58
Happy Meadows	672	100 yr	1610.00	7832.10	7835.99		7836.52	0.005173	5.94	285.30	110.57	0.59
Happy Meadows	672	500-yr	2335.00	7832.10	7836.68		7837.38	0.005261	6.86	387.87	126.33	0.62
Happy Meadows	671.5	min	32.00	7828.69	7829.68		7829.78	0.009543	2.48	12.90	24.39	0.60
Happy Meadows	671.5	1-yr	160.00	7828.69	7830.43	7830.25	7830.71	0.012910	4.28	37.54	39.22	0.77
Happy Meadows	671.5	2-yr	426.00	7828.69	7831.18	7831.18	7831.68	0.020819	5.78	73.99	70.62	0.99
Happy Meadows	671.5	5 yr	660.00	7828.69	7831.55	7831.55	7832.19	0.020104	6.44	107.57	81.08	1.01
Happy Meadows	671.5	10-yr	846.00	7828.69	7831.78	7831.78	7832.52	0.019937	6.91	122.97	86.54	1.01
Happy Meadows	671.5	50-yr	1351.00	7828.69	7832.32	7832.32	7833.32	0.017444	8.04	169.17	97.92	1.01
Happy Meadows	671.5	100 yr	1610.00	7828.69	7832.57	7832.57	7833.68	0.016589	8.49	191.28	99.59	1.00
Happy Meadows	671.5	500-yr	2335.00	7828.69	7833.21	7833.21	7834.60	0.014843	9.51	249.94	95.10	0.99
Happy Meadows	671.3	min	32.00	7826.74	7827.80	7827.80	7827.86	0.031678	3.18	10.07	35.13	1.05
Happy Meadows	671.3	1-yr	160.00	7826.74	7828.37	7828.37	7828.62	0.028184	4.35	38.74	66.90	1.04
Happy Meadows	671.3	2-yr	426.00	7826.74	7828.89	7828.87	7829.33	0.019359	5.30	80.51	90.82	0.99
Happy Meadows	671.3	5 yr	660.00	7826.74	7829.24	7829.18	7829.77	0.015892	5.87	113.02	95.72	0.94
Happy Meadows	671.3	10-yr	846.00	7826.74	7829.48	7829.39	7830.08	0.015388	6.24	136.64	98.11	0.90
Happy Meadows	671.3	50-yr	1351.00	7826.74	7830.09	7829.90	7830.83	0.012604	6.93	196.00	104.64	0.87
Happy Meadows	671.3	100 yr	1610.00	7826.74	7830.33	7830.14	7831.15	0.012502	7.32	223.99	110.57	0.88
Happy Meadows	671.3	500-yr	2335.00	7826.74	7830.83	7830.81	7831.91	0.013885	8.39	284.74	131.71	0.98
Happy Meadows	671	min	32.00	7824.85	7826.19	7825.83	7826.27	0.004937	2.26	14.14	18.28	0.49
Happy Meadows	671	1-yr	160.00	7824.85	7827.27	7826.80	7827.36	0.005652	2.43	65.94	86.99	0.49
Happy Meadows	671	2-yr	426.00	7824.85	7827.78	7827.45	7827.98	0.007817	3.61	118.04	109.58	0.61
Happy Meadows	671	5 yr	660.00	7824.85	7828.02	7827.73	7828.35	0.009730	4.57	144.46	110.89	0.71
Happy Meadows	671	10-yr	846.00	7824.85	7828.18	7827.93	7828.60	0.011421	5.26	160.28	111.87	0.78
Happy Meadows	671	50-yr	1351.00	7824.85	7828.41	7828.39	7829.21	0.017444	7.21	187.54	113.07	0.98
Happy Meadows	671	100 yr	1610.00	7824.85	7828.58	7828.58	7829.52	0.018316	7.79	206.84	114.05	1.00
Happy Meadows	671	500-yr	2335.00	7824.85	7829.13	7829.13	7830.39	0.018300	8.69	268.45	118.13	1.00
Happy Meadows	670	min	32.00	7817.82	7818.49	7818.49	7818.61	0.032318	2.70	11.86	49.57	0.97
Happy Meadows	670	1-yr	160.00	7817.82	7818.92	7818.92	7819.18	0.029401	3.91	40.90	91.29	1.03
Happy Meadows	670	2-yr	426.00	7817.82	7819.43	7819.33	7819.74	0.016526	4.53	94.12	109.50	0.88

HEC-RAS Plan: Plan 01 River: South Platte Reach: Happy Meadows (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Happy Meadows	670	5 yr	660.00	7817.82	7819.90	7819.80	7820.17	0.012280	4.88	135.18	112.04	0.78
Happy Meadows	670	10 yr	846.00	7817.82	7820.08		7820.48	0.013272	5.07	166.99	114.24	0.74
Happy Meadows	670	50 yr	1351.00	7817.82	7820.81		7821.26	0.009860	5.36	252.09	118.04	0.65
Happy Meadows	670	100 yr	1610.00	7817.82	7821.12		7821.60	0.008339	5.59	288.33	119.48	0.63
Happy Meadows	670	500 yr	2335.00	7817.82	7821.89		7822.48	0.005290	6.14	383.41	126.34	0.60
Happy Meadows	669.5	min	32.00	7814.51	7815.64		7815.67	0.002713	1.35	23.78	44.07	0.32
Happy Meadows	669.5	1 yr	160.00	7814.51	7816.36		7816.47	0.004232	2.64	60.65	57.08	0.45
Happy Meadows	669.5	2 yr	426.00	7814.51	7817.12		7817.38	0.004939	4.08	104.94	58.53	0.53
Happy Meadows	669.5	5 yr	660.00	7814.51	7817.84		7818.01	0.005120	4.91	136.00	81.30	0.57
Happy Meadows	669.5	10 yr	846.00	7814.51	7818.00		7818.48	0.005184	5.44	158.37	82.70	0.58
Happy Meadows	669.5	50 yr	1351.00	7814.51	7818.81		7819.48	0.005468	6.65	213.75	89.36	0.63
Happy Meadows	669.5	100 yr	1610.00	7814.51	7819.17		7819.92	0.005410	7.06	248.02	98.23	0.63
Happy Meadows	669.5	500 yr	2335.00	7814.51	7820.02		7820.94	0.005301	7.98	338.82	120.85	0.65
Happy Meadows	669	min	32.00	7813.48	7814.42		7814.44	0.001908	0.97	33.06	77.18	0.26
Happy Meadows	669	1 yr	160.00	7813.48	7815.20		7815.24	0.001381	1.45	110.29	108.80	0.25
Happy Meadows	669	2 yr	426.00	7813.48	7816.32		7816.37	0.000880	1.77	241.02	127.91	0.23
Happy Meadows	669	5 yr	660.00	7813.48	7816.94		7817.01	0.000820	2.06	321.10	129.89	0.23
Happy Meadows	669	10 yr	846.00	7813.48	7817.35		7817.43	0.000817	2.27	375.18	133.04	0.23
Happy Meadows	669	50 yr	1351.00	7813.48	7818.25		7818.37	0.000845	2.78	497.46	140.97	0.25
Happy Meadows	669	100 yr	1610.00	7813.48	7818.63		7818.78	0.000871	2.99	552.48	148.45	0.26
Happy Meadows	669	500 yr	2335.00	7813.48	7819.51		7819.70	0.000944	3.53	688.59	157.95	0.28
Happy Meadows	668	min	32.00	7812.81	7813.67		7813.72	0.005839	1.52	21.04	57.40	0.44
Happy Meadows	668	1 yr	160.00	7812.81	7814.95		7814.98	0.000898	1.33	123.03	103.57	0.21
Happy Meadows	668	2 yr	426.00	7812.81	7816.14		7816.18	0.000731	1.60	266.15	140.67	0.20
Happy Meadows	668	5 yr	660.00	7812.81	7816.78		7816.83	0.000665	1.85	356.88	142.36	0.20
Happy Meadows	668	10 yr	846.00	7812.81	7817.19		7817.26	0.000658	2.04	416.32	144.91	0.21
Happy Meadows	668	50 yr	1351.00	7812.81	7818.08		7818.18	0.000695	2.50	546.65	148.96	0.22
Happy Meadows	668	100 yr	1610.00	7812.81	7818.46		7818.57	0.000721	2.71	607.80	151.07	0.23
Happy Meadows	668	500 yr	2335.00	7812.81	7819.33		7819.49	0.000803	3.24	736.62	156.22	0.25
Happy Meadows	667	min	32.00	7811.98	7813.54		7813.56	0.000436	0.71	45.37	55.53	0.14
Happy Meadows	667	1 yr	160.00	7811.98	7814.87		7814.89	0.000485	1.15	139.69	88.82	0.16
Happy Meadows	667	2 yr	426.00	7811.98	7816.05		7816.09	0.000555	1.66	258.12	108.27	0.19
Happy Meadows	667	5 yr	660.00	7811.98	7816.68		7816.74	0.000631	2.04	326.27	114.47	0.20
Happy Meadows	667	10 yr	846.00	7811.98	7817.08		7817.17	0.000672	2.30	375.69	119.29	0.22
Happy Meadows	667	50 yr	1351.00	7811.98	7817.95		7818.07	0.000803	2.91	482.63	129.07	0.25
Happy Meadows	667	100 yr	1610.00	7811.98	7818.31		7818.48	0.000865	3.19	529.93	133.46	0.26
Happy Meadows	667	500 yr	2335.00	7811.98	7819.14		7819.38	0.001024	3.88	646.06	142.89	0.29
Happy Meadows	666	min	32.00	7811.75	7813.39		7813.39	0.000398	0.63	50.51	68.73	0.13
Happy Meadows	666	1 yr	160.00	7811.75	7814.73		7814.75	0.000313	1.08	148.18	74.72	0.14
Happy Meadows	666	2 yr	426.00	7811.75	7815.94		7815.90	0.000496	1.82	240.59	98.24	0.18
Happy Meadows	666	5 yr	660.00	7811.75	7816.43		7816.51	0.000643	2.32	301.30	110.08	0.21
Happy Meadows	666	10 yr	846.00	7811.75	7816.79		7816.90	0.000744	2.67	343.74	119.97	0.23
Happy Meadows	666	50 yr	1351.00	7811.75	7817.57		7817.74	0.000990	3.48	448.91	197.78	0.28
Happy Meadows	666	100 yr	1610.00	7811.75	7817.90		7818.10	0.001070	3.78	502.95	197.27	0.29
Happy Meadows	666	500 yr	2335.00	7811.75	7818.67		7818.94	0.001344	4.45	638.40	183.91	0.32
Happy Meadows	665	min	32.00	7810.92	7813.32		7813.33	0.000228	0.73	43.73	30.91	0.11
Happy Meadows	665	1 yr	160.00	7810.92	7814.62		7814.65	0.000827	1.48	108.68	83.30	0.19
Happy Meadows	665	2 yr	426.00	7810.92	7815.67		7815.75	0.000904	2.33	205.53	118.45	0.24
Happy Meadows	665	5 yr	660.00	7810.92	7816.22		7816.33	0.001085	2.84	271.71	127.12	0.27
Happy Meadows	665	10 yr	846.00	7810.92	7816.57		7816.71	0.001201	3.19	317.62	144.25	0.29
Happy Meadows	665	50 yr	1351.00	7810.92	7817.31		7817.50	0.001397	3.88	448.90	185.14	0.32
Happy Meadows	665	100 yr	1610.00	7810.92	7817.63		7817.84	0.001457	4.15	512.12	202.39	0.33
Happy Meadows	665	500 yr	2335.00	7810.92	7818.41		7818.66	0.001486	4.65	676.45	220.88	0.35
Happy Meadows	664	min	32.00	7811.56	7813.30		7813.32	0.000919	1.09	29.35	33.05	0.20
Happy Meadows	664	1 yr	160.00	7811.56	7814.29		7814.36	0.002196	2.17	73.84	56.84	0.34
Happy Meadows	664	2 yr	426.00	7811.56	7815.24		7815.35	0.002655	2.70	157.59	100.84	0.38
Happy Meadows	664	5 yr	660.00	7811.56	7815.75		7815.90	0.002577	3.16	209.40	105.07	0.39
Happy Meadows	664	10 yr	846.00	7811.56	7816.04		7816.24	0.002837	3.53	241.31	108.66	0.41
Happy Meadows	664	50 yr	1351.00	7811.56	7816.63		7816.84	0.003149	4.48	307.06	116.23	0.46
Happy Meadows	664	100 yr	1610.00	7811.56	7816.89		7817.26	0.003375	4.90	337.09	122.20	0.48
Happy Meadows	664	500 yr	2335.00	7811.56	7817.48		7818.01	0.003912	5.91	414.43	137.75	0.54
Happy Meadows	663	min	32.00	7811.78	7813.06		7813.07	0.000343	1.13	28.47	59.81	0.29
Happy Meadows	663	1 yr	160.00	7811.78	7814.20		7814.23	0.000791	1.24	128.80	98.20	0.19
Happy Meadows	663	2 yr	426.00	7811.78	7815.14		7815.19	0.000825	1.92	229.87	111.30	0.23
Happy Meadows	663	5 yr	660.00	7811.78	7815.63		7815.72	0.000991	2.41	283.08	118.74	0.26
Happy Meadows	663	10 yr	846.00	7811.78	7815.90		7816.04	0.001151	2.77	316.78	118.41	0.28
Happy Meadows	663	50 yr	1351.00	7811.78	7816.47		7816.68	0.001832	3.69	383.24	121.84	0.34

HEC-RAS Plan: Plan 01 River: South Platte Reach: Happy Meadows (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Happy Meadows	663	100-yr	1610.00	7811.78	7818.71		7818.96	0.001885	4.11	411.88	126.96	0.37
Happy Meadows	663	500-yr	2335.00	7811.78	7817.25		7817.65	0.002446	5.15	480.78	147.78	0.43
Happy Meadows	662	min	32.00	7811.19	7812.91		7812.93	0.001025	1.06	30.22	38.53	0.21
Happy Meadows	662	1-yr	160.00	7811.19	7814.14		7814.16	0.000640	1.31	132.57	98.44	0.18
Happy Meadows	662	2-yr	426.00	7811.19	7815.08		7815.11	0.000795	1.89	330.40	133.88	0.22
Happy Meadows	662	5 yr	660.00	7811.19	7815.54		7815.57	0.000942	2.34	305.97	164.55	0.25
Happy Meadows	662	10-yr	846.00	7811.19	7815.82		7815.92	0.001071	2.99	353.29	174.38	0.27
Happy Meadows	662	50-yr	1351.00	7811.19	7816.35		7816.52	0.001443	3.44	447.13	180.54	0.32
Happy Meadows	662	100-yr	1610.00	7811.19	7816.57		7816.77	0.001604	3.78	488.06	183.18	0.34
Happy Meadows	662	500-yr	2335.00	7811.19	7817.11		7817.40	0.001990	4.60	587.94	189.40	0.39
Happy Meadows	661	min	32.00	7811.19	7812.87		7812.89	0.000875	0.83	38.77	63.57	0.19
Happy Meadows	661	1-yr	160.00	7811.19	7814.08		7814.10	0.000527	1.01	158.20	133.45	0.16
Happy Meadows	661	2-yr	426.00	7811.19	7815.01		7815.03	0.000591	1.35	319.99	195.81	0.18
Happy Meadows	661	5 yr	660.00	7811.19	7815.50		7815.54	0.000600	1.61	417.54	201.37	0.19
Happy Meadows	661	10-yr	846.00	7811.19	7815.77		7815.87	0.000660	1.83	473.32	204.33	0.20
Happy Meadows	661	50-yr	1351.00	7811.19	7816.29		7816.38	0.000873	2.39	580.64	207.65	0.24
Happy Meadows	661	100-yr	1610.00	7811.19	7816.52		7816.62	0.000970	2.64	626.93	209.06	0.26
Happy Meadows	661	500-yr	2335.00	7811.19	7817.09		7817.21	0.001207	3.29	738.89	212.44	0.30
Happy Meadows	660	min	32.00	7810.88	7812.75		7812.78	0.000533	0.74	43.04	57.19	0.15
Happy Meadows	660	1-yr	160.00	7810.88	7814.02		7814.04	0.000686	1.11	144.74	125.57	0.18
Happy Meadows	660	2-yr	426.00	7810.88	7814.94		7814.97	0.000783	1.35	315.94	225.79	0.20
Happy Meadows	660	5 yr	660.00	7810.88	7815.44		7815.47	0.000877	1.54	430.06	232.31	0.20
Happy Meadows	660	10-yr	846.00	7810.88	7815.71		7815.75	0.000729	1.72	493.40	233.51	0.21
Happy Meadows	660	50-yr	1351.00	7810.88	7816.21		7816.29	0.000884	2.21	611.85	239.73	0.24
Happy Meadows	660	100-yr	1610.00	7810.88	7816.43		7816.52	0.000965	2.44	662.71	238.87	0.25
Happy Meadows	660	500-yr	2335.00	7810.88	7816.94		7817.08	0.001165	2.99	785.10	238.93	0.29
Happy Meadows	137	min	32.00	7811.10	7812.70		7812.72	0.000883	1.06	30.16	34.35	0.20
Happy Meadows	137	1-yr	160.00	7811.10	7813.93		7813.96	0.002361	1.34	120.81	218.93	0.31
Happy Meadows	137	2-yr	426.00	7811.10	7814.90		7814.92	0.000595	1.28	344.49	235.84	0.18
Happy Meadows	137	5 yr	660.00	7811.10	7815.40		7815.43	0.000545	1.47	463.44	238.59	0.18
Happy Meadows	137	10-yr	846.00	7811.10	7815.67		7815.71	0.000585	1.66	528.05	240.01	0.19
Happy Meadows	137	50-yr	1351.00	7811.10	7816.19		7816.23	0.000771	2.18	647.48	244.27	0.23
Happy Meadows	137	100-yr	1610.00	7811.10	7816.37		7816.46	0.000856	2.39	698.89	246.30	0.24
Happy Meadows	137	500-yr	2335.00	7811.10	7816.87		7817.00	0.001063	2.94	804.39	251.17	0.28
Happy Meadows	136	min	32.00	7810.88	7812.65		7812.68	0.000411	0.87	36.75	32.95	0.14
Happy Meadows	136	1-yr	160.00	7810.88	7813.76		7813.80	0.001414	1.55	103.52	84.42	0.26
Happy Meadows	136	2-yr	426.00	7810.88	7814.82		7814.86	0.000862	1.41	305.76	230.59	0.21
Happy Meadows	136	5 yr	660.00	7810.88	7815.33		7815.37	0.000713	1.58	425.65	240.65	0.20
Happy Meadows	136	10-yr	846.00	7810.88	7815.60		7815.65	0.000747	1.77	490.36	246.48	0.21
Happy Meadows	136	50-yr	1351.00	7810.88	7816.07		7816.15	0.000968	2.29	608.93	256.82	0.25
Happy Meadows	136	100-yr	1610.00	7810.88	7816.27		7816.37	0.001086	2.63	660.66	261.23	0.27
Happy Meadows	136	500-yr	2335.00	7810.88	7816.75		7816.89	0.001300	3.10	788.29	271.72	0.30
Happy Meadows	135	min	32.00	7811.38	7812.34	7812.34	7812.55	0.029952	3.69	8.67	21.23	1.02
Happy Meadows	135	1-yr	160.00	7811.38	7813.05	7813.05	7813.50	0.033310	5.38	29.72	34.15	1.02
Happy Meadows	135	2-yr	426.00	7811.38	7813.96	7813.96	7814.63	0.030760	8.53	85.21	50.41	1.01
Happy Meadows	135	5 yr	660.00	7811.38	7814.54	7814.54	7815.17	0.030940	8.37	103.81	88.99	1.01
Happy Meadows	135	10-yr	846.00	7811.38	7814.99	7814.99	7815.46	0.020244	5.53	154.56	161.25	0.86
Happy Meadows	135	50-yr	1351.00	7811.38	7815.35	7815.35	7815.82	0.020815	6.07	226.11	209.94	1.01
Happy Meadows	135	100-yr	1610.00	7811.38	7815.51	7815.51	7816.12	0.019837	6.31	259.94	220.47	1.00
Happy Meadows	135	500-yr	2335.00	7811.38	7815.87	7815.87	7816.61	0.018339	6.96	343.48	244.21	1.00
Happy Meadows	134	min	32.00	7809.40	7809.73		7809.81	0.070569	2.33	13.75	51.39	0.79
Happy Meadows	134	1-yr	160.00	7809.40	7810.12	7810.12	7810.39	0.026883	4.18	38.31	72.84	1.01
Happy Meadows	134	2-yr	426.00	7809.40	7810.62	7810.62	7811.06	0.022989	5.28	80.64	95.47	1.01
Happy Meadows	134	5 yr	660.00	7809.40	7811.04	7810.92	7811.48	0.014891	5.36	123.17	103.37	0.87
Happy Meadows	134	10-yr	846.00	7809.40	7811.48		7811.86	0.009321	4.99	169.51	111.34	0.71
Happy Meadows	134	50-yr	1351.00	7809.40	7812.55		7812.87	0.004351	4.51	299.47	139.08	0.52
Happy Meadows	134	100-yr	1610.00	7809.40	7813.14		7813.47	0.003117	4.26	377.80	137.84	0.45
Happy Meadows	134	500-yr	2335.00	7809.40	7814.70		7814.93	0.001629	3.82	612.41	166.48	0.35
Happy Meadows	133	min	32.00	7807.85	7808.75	7808.73	7808.86	0.025828	2.50	12.79	50.83	0.88
Happy Meadows	133	1-yr	160.00	7807.85	7809.37		7809.53	0.010756	3.21	49.80	70.32	0.67
Happy Meadows	133	2-yr	426.00	7807.85	7810.35		7810.51	0.004637	3.18	134.90	104.81	0.49
Happy Meadows	133	5 yr	660.00	7807.85	7810.99		7811.15	0.003271	3.18	209.12	127.04	0.43
Happy Meadows	133	10-yr	846.00	7807.85	7811.45		7811.60	0.002597	3.18	270.97	141.77	0.39
Happy Meadows	133	50-yr	1351.00	7807.85	7812.57		7812.72	0.001483	3.19	440.33	161.81	0.32
Happy Meadows	133	100-yr	1610.00	7807.85	7813.16		7813.31	0.001143	3.16	540.56	161.67	0.29
Happy Meadows	133	500-yr	2335.00	7807.85	7814.73		7814.86	0.000655	3.03	875.51	239.63	0.23

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HEC-RAS Plan: Plan 01 River: South Platte Reach: Happy Meadows (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Happy Meadows	132	min	28.00	7806.37	7807.28	7806.98	7807.33	0.004151	1.79	15.63	25.87	0.41
Happy Meadows	132	1-yr	156.00	7806.37	7808.48	7807.72	7808.60	0.003272	2.84	55.36	42.30	0.42
Happy Meadows	132	2-yr	422.00	7806.37	7809.37	7808.62	7809.70	0.004691	4.67	93.39	46.22	0.54
Happy Meadows	132	5 yr	654.00	7806.37	7809.95	7809.16	7810.44	0.005144	5.68	122.06	51.75	0.59
Happy Meadows	132	10-yr	842.00	7806.37	7810.39	7809.58	7810.96	0.005157	6.24	145.28	54.75	0.60
Happy Meadows	132	50-yr	1347.00	7806.37	7811.58	7810.48	7812.27	0.004291	6.98	213.50	58.35	0.58
Happy Meadows	132	100 yr	1606.00	7806.37	7812.21	7810.85	7812.93	0.003768	7.13	250.62	58.78	0.56
Happy Meadows	132	500-yr	2331.00	7806.37	7813.76	7811.77	7814.58	0.003110	7.72	350.14	70.22	0.52
Happy Meadows	131.5		Bridge									
Happy Meadows	131	min	28.00	7805.22	7807.21		7807.24	0.001336	1.27	22.05	22.70	0.23
Happy Meadows	131	1-yr	156.00	7805.22	7808.39		7808.50	0.002663	2.57	60.62	38.05	0.38
Happy Meadows	131	2-yr	422.00	7805.22	7809.15		7809.49	0.005251	4.89	91.34	42.05	0.54
Happy Meadows	131	5 yr	654.00	7805.22	7809.59		7810.16	0.007025	6.08	110.33	44.58	0.64
Happy Meadows	131	10-yr	842.00	7805.22	7809.87		7810.64	0.008391	7.07	122.95	46.10	0.71
Happy Meadows	131	50-yr	1347.00	7805.22	7810.41	7810.21	7811.77	0.012240	9.51	148.38	48.71	0.88
Happy Meadows	131	100 yr	1606.00	7805.22	7810.62	7810.62	7812.33	0.014261	10.65	158.68	49.79	0.96
Happy Meadows	131	500-yr	2331.00	7805.22	7811.75	7811.75	7813.71	0.011885	11.57	224.06	66.95	0.92
Happy Meadows	130	min	28.00	7805.71	7806.86		7806.81	0.014728	3.17	8.84	16.06	0.75
Happy Meadows	130	1-yr	156.00	7805.71	7807.39	7807.39	7807.69	0.024576	4.37	35.68	58.92	0.99
Happy Meadows	130	2-yr	422.00	7805.71	7808.18		7808.52	0.011421	4.68	90.08	74.93	0.75
Happy Meadows	130	5 yr	654.00	7805.71	7808.70		7809.10	0.008636	5.04	129.70	77.93	0.69
Happy Meadows	130	10-yr	842.00	7805.71	7809.08		7809.51	0.007421	5.29	159.32	80.43	0.66
Happy Meadows	130	50-yr	1347.00	7805.71	7809.88		7810.44	0.006156	6.02	227.71	94.85	0.63
Happy Meadows	130	100 yr	1606.00	7805.71	7810.21		7810.83	0.005906	6.36	261.28	104.35	0.63
Happy Meadows	130	500-yr	2331.00	7805.71	7810.96		7811.72	0.005615	7.15	363.72	150.85	0.64
Happy Meadows	129	min	28.00	7803.60	7804.50		7804.53	0.003000	1.38	20.31	39.26	0.34
Happy Meadows	129	1-yr	156.00	7803.60	7805.61		7805.68	0.002052	2.12	73.72	55.74	0.32
Happy Meadows	129	2-yr	422.00	7803.60	7806.83		7806.95	0.001888	2.77	152.12	71.78	0.34
Happy Meadows	129	5 yr	654.00	7803.60	7807.48		7807.65	0.001879	3.27	200.19	75.70	0.35
Happy Meadows	129	10-yr	842.00	7803.60	7807.92		7808.13	0.001885	3.62	236.10	97.79	0.36
Happy Meadows	129	50-yr	1347.00	7803.60	7808.92		7809.17	0.001739	4.17	364.25	154.31	0.36
Happy Meadows	129	100 yr	1606.00	7803.60	7809.33		7809.60	0.001681	4.37	433.53	182.75	0.36
Happy Meadows	129	500-yr	2331.00	7803.60	7810.14		7810.47	0.001707	4.91	593.18	200.97	0.37
Happy Meadows	128	min	28.00	7802.29	7803.47		7803.49	0.001466	1.15	24.41	38.17	0.25
Happy Meadows	128	1-yr	156.00	7802.29	7804.48		7804.56	0.002370	2.35	66.42	47.98	0.35
Happy Meadows	128	2-yr	422.00	7802.29	7805.55		7805.74	0.003005	3.59	120.57	58.52	0.42
Happy Meadows	128	5 yr	654.00	7802.29	7806.19		7806.45	0.002970	4.09	165.32	75.30	0.44
Happy Meadows	128	10-yr	842.00	7802.29	7806.64		7806.94	0.002866	4.45	199.88	79.95	0.44
Happy Meadows	128	50-yr	1347.00	7802.29	7807.65		7808.05	0.002740	5.23	293.28	122.27	0.45
Happy Meadows	128	100 yr	1606.00	7802.29	7808.08		7808.51	0.002668	5.51	354.57	169.58	0.45
Happy Meadows	128	500-yr	2331.00	7802.29	7808.96		7809.41	0.002451	5.93	519.13	199.50	0.45
Happy Meadows	127	min	28.00	7800.11	7800.74	7800.74	7800.92	0.030088	3.38	8.32	23.75	1.00
Happy Meadows	127	1-yr	156.00	7800.11	7801.85		7802.05	0.007328	3.56	43.81	39.64	0.60
Happy Meadows	127	2-yr	422.00	7800.11	7803.20		7803.46	0.004166	4.05	104.25	50.80	0.50
Happy Meadows	127	5 yr	654.00	7800.11	7803.92		7804.25	0.003873	4.63	141.29	52.69	0.50
Happy Meadows	127	10-yr	842.00	7800.11	7804.41		7804.80	0.003788	5.03	167.57	55.32	0.50
Happy Meadows	127	50-yr	1347.00	7800.11	7805.46		7806.01	0.003620	5.97	231.73	74.24	0.52
Happy Meadows	127	100 yr	1606.00	7800.11	7805.92		7806.52	0.003485	6.29	279.11	117.80	0.52
Happy Meadows	127	500-yr	2331.00	7800.11	7807.13		7807.72	0.002715	6.49	444.51	154.65	0.47
Happy Meadows	126	min	28.00	7798.43	7799.69		7799.71	0.000763	0.99	28.39	32.31	0.19
Happy Meadows	126	1-yr	156.00	7798.43	7801.10		7801.18	0.001048	1.95	79.80	40.88	0.25
Happy Meadows	126	2-yr	422.00	7798.43	7802.23		7802.39	0.001882	3.21	132.28	51.68	0.35
Happy Meadows	126	5 yr	654.00	7798.43	7802.87		7803.12	0.002217	3.99	165.78	52.74	0.39
Happy Meadows	126	10-yr	842.00	7798.43	7803.30		7803.62	0.002458	4.53	188.51	53.75	0.42
Happy Meadows	126	50-yr	1347.00	7798.43	7804.25		7804.75	0.002888	5.72	241.85	58.19	0.47
Happy Meadows	126	100 yr	1606.00	7798.43	7804.67		7805.26	0.003052	6.23	267.08	62.52	0.49
Happy Meadows	126	500-yr	2331.00	7798.43	7805.73		7806.54	0.003310	7.36	341.28	89.70	0.52
Happy Meadows	125	min	28.00	7798.22	7799.33		7799.38	0.002936	1.70	16.48	22.70	0.35
Happy Meadows	125	1-yr	156.00	7798.22	7800.59		7800.71	0.003921	2.89	58.00	50.01	0.44
Happy Meadows	125	2-yr	422.00	7798.22	7801.39		7801.65	0.005318	4.13	102.08	57.75	0.55
Happy Meadows	125	5 yr	654.00	7798.22	7801.85		7802.25	0.006109	5.05	129.44	59.97	0.61
Happy Meadows	125	10-yr	842.00	7798.22	7802.12		7802.64	0.007092	5.79	145.42	61.31	0.66
Happy Meadows	125	50-yr	1347.00	7798.22	7802.67		7803.54	0.009332	7.47	180.33	64.01	0.78
Happy Meadows	125	100 yr	1606.00	7798.22	7802.91		7803.96	0.010315	8.23	195.45	65.82	0.83
Happy Meadows	125	500-yr	2331.00	7798.22	7803.43	7803.32	7805.03	0.012771	10.17	231.08	70.09	0.95
Happy Meadows	124	min	28.00	7796.98	7797.97		7797.98	0.001450	0.88	32.52	73.72	0.23

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HEC-RAS Plan: Plan 01 River: South Platte Reach: Happy Meadows (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Happy Meadows	124	1-yr	156.00	7796.98	7798.67		7798.71	0.002177	1.62	96.08	112.62	0.31
Happy Meadows	124	2-yr	422.00	7796.98	7799.46		7799.53	0.001928	2.15	196.06	136.22	0.32
Happy Meadows	124	5 yr	654.00	7796.98	7799.98		7800.07	0.001805	2.39	274.08	156.19	0.32
Happy Meadows	124	10-yr	842.00	7796.98	7800.33		7800.43	0.001671	2.58	328.12	159.60	0.31
Happy Meadows	124	50-yr	1347.00	7796.98	7801.14		7801.28	0.001443	2.95	481.79	167.83	0.31
Happy Meadows	124	100 yr	1606.00	7796.98	7801.52		7801.67	0.001366	3.10	525.72	171.38	0.30
Happy Meadows	124	500-yr	2331.00	7796.98	7802.47		7802.65	0.001218	3.44	708.00	218.49	0.30
Happy Meadows	123	anin	28.00	7794.86	7795.75	7795.75	7796.94	0.028898	3.56	7.87	19.97	1.00
Happy Meadows	123	1-yr	156.00	7794.86	7796.77		7796.91	0.006307	2.98	52.28	55.12	0.54
Happy Meadows	123	2-yr	422.00	7794.86	7797.74		7797.97	0.005178	3.88	108.89	86.16	0.53
Happy Meadows	123	5 yr	654.00	7794.86	7798.31		7798.61	0.004792	4.43	147.81	89.34	0.54
Happy Meadows	123	10-yr	842.00	7794.86	7798.69		7799.05	0.004616	4.83	175.01	75.10	0.54
Happy Meadows	123	50-yr	1347.00	7794.86	7799.54		7800.04	0.004312	5.68	243.98	84.75	0.56
Happy Meadows	123	100 yr	1606.00	7794.86	7799.92		7800.48	0.004209	6.03	276.86	88.05	0.56
Happy Meadows	123	500-yr	2331.00	7794.86	7800.82		7801.53	0.004137	6.91	358.71	95.06	0.57
Happy Meadows	122	anin	28.00	7792.56	7794.57		7794.58	0.001159	0.98	28.53	43.02	0.21
Happy Meadows	122	1-yr	156.00	7792.56	7795.39		7795.46	0.002521	2.09	74.48	61.55	0.34
Happy Meadows	122	2-yr	422.00	7792.56	7796.20		7796.38	0.003412	3.34	126.47	63.98	0.42
Happy Meadows	122	5 yr	654.00	7792.56	7796.73		7796.99	0.003798	4.08	160.45	65.87	0.46
Happy Meadows	122	10-yr	842.00	7792.56	7797.09		7797.42	0.003978	4.57	184.80	67.97	0.48
Happy Meadows	122	50-yr	1347.00	7792.56	7797.90		7798.40	0.004353	5.66	243.09	78.08	0.52
Happy Meadows	122	100 yr	1606.00	7792.56	7798.28		7798.83	0.004498	6.11	272.48	88.56	0.54
Happy Meadows	122	500-yr	2331.00	7792.56	7799.08		7799.84	0.004788	7.15	354.04	108.97	0.57
Happy Meadows	121	anin	28.00	7793.42	7794.26		7794.31	0.007937	1.79	15.62	42.09	0.52
Happy Meadows	121	1-yr	156.00	7793.42	7795.00		7795.09	0.004477	2.34	66.75	78.07	0.45
Happy Meadows	121	2-yr	422.00	7793.42	7795.81		7795.97	0.003830	3.23	130.74	83.14	0.45
Happy Meadows	121	5 yr	654.00	7793.42	7796.38		7796.57	0.003527	3.70	178.78	85.92	0.45
Happy Meadows	121	10-yr	842.00	7793.42	7796.74		7796.99	0.003314	4.00	210.56	88.24	0.45
Happy Meadows	121	50-yr	1347.00	7793.42	7797.61		7797.95	0.003016	4.68	293.98	105.84	0.45
Happy Meadows	121	100 yr	1606.00	7793.42	7797.99		7798.37	0.002931	4.97	337.13	120.11	0.46
Happy Meadows	121	500-yr	2331.00	7793.42	7798.90		7799.36	0.002782	5.58	454.02	136.26	0.48
Happy Meadows	120	anin	28.00	7791.27	7792.33		7792.35	0.001747	1.04	27.04	53.18	0.26
Happy Meadows	120	1-yr	156.00	7791.27	7793.12		7793.18	0.002352	2.02	77.18	68.34	0.34
Happy Meadows	120	2-yr	422.00	7791.27	7794.07		7794.21	0.002294	2.95	143.38	71.32	0.38
Happy Meadows	120	5 yr	654.00	7791.27	7794.67		7794.86	0.002331	3.52	187.19	75.14	0.38
Happy Meadows	120	10-yr	842.00	7791.27	7795.08		7795.30	0.002430	3.94	217.71	81.95	0.40
Happy Meadows	120	50-yr	1347.00	7791.27	7795.90		7796.26	0.002851	4.85	292.80	98.04	0.43
Happy Meadows	120	100 yr	1606.00	7791.27	7796.24		7796.65	0.002792	5.26	327.08	105.41	0.45
Happy Meadows	120	500-yr	2331.00	7791.27	7796.99		7797.57	0.003190	6.27	412.79	121.84	0.50
Happy Meadows	119	anin	28.00	7790.37	7791.03		7791.07	0.005581	1.50	18.66	50.56	0.44
Happy Meadows	119	1-yr	156.00	7790.37	7791.85		7791.94	0.003353	2.42	64.38	57.47	0.40
Happy Meadows	119	2-yr	422.00	7790.37	7792.93		7793.09	0.002758	3.19	132.51	68.92	0.40
Happy Meadows	119	5 yr	654.00	7790.37	7793.58		7793.79	0.002499	3.67	186.96	119.26	0.40
Happy Meadows	119	10-yr	842.00	7790.37	7794.04		7794.26	0.002224	3.86	244.16	129.02	0.39
Happy Meadows	119	50-yr	1347.00	7790.37	7795.06		7795.28	0.001703	4.08	416.49	210.69	0.38
Happy Meadows	119	100 yr	1606.00	7790.37	7795.48		7795.68	0.001560	4.16	504.90	226.33	0.39
Happy Meadows	119	500-yr	2331.00	7790.37	7796.31		7796.55	0.001436	4.48	711.40	258.14	0.34
Happy Meadows	118	anin	28.00	7788.90	7789.77		7789.81	0.002744	1.44	19.47	32.99	0.33
Happy Meadows	118	1-yr	156.00	7788.90	7790.88		7790.97	0.002583	2.42	84.50	47.75	0.37
Happy Meadows	118	2-yr	422.00	7788.90	7791.91		7792.12	0.003049	3.62	119.61	53.03	0.43
Happy Meadows	118	5 yr	654.00	7788.90	7792.57		7792.86	0.003101	4.33	152.56	58.20	0.45
Happy Meadows	118	10-yr	842.00	7788.90	7793.02		7793.38	0.003109	4.78	180.57	64.52	0.48
Happy Meadows	118	50-yr	1347.00	7788.90	7794.06		7794.52	0.002992	5.81	270.85	117.57	0.47
Happy Meadows	118	100 yr	1606.00	7788.90	7794.51		7794.98	0.002784	5.78	348.50	210.85	0.46
Happy Meadows	118	500-yr	2331.00	7788.90	7795.61		7795.99	0.001960	5.55	602.27	246.26	0.40
Happy Meadows	117	anin	28.00	7788.91	7788.14	7787.76	7788.20	0.004702	2.00	14.02	21.65	0.44
Happy Meadows	117	1-yr	156.00	7788.91	7789.26	7788.71	7789.38	0.004856	2.84	54.95	51.31	0.48
Happy Meadows	117	2-yr	422.00	7788.91	7790.24	7789.46	7790.49	0.004225	3.98	106.13	52.86	0.49
Happy Meadows	117	5 yr	654.00	7788.91	7790.87	7789.93	7791.21	0.004224	4.88	139.66	53.78	0.51
Happy Meadows	117	10-yr	842.00	7788.91	7791.30	7790.23	7791.72	0.004266	5.18	163.12	54.94	0.53
Happy Meadows	117	50-yr	1347.00	7788.91	7792.28	7790.95	7792.86	0.004423	6.24	216.93	58.09	0.56
Happy Meadows	117	100 yr	1606.00	7788.91	7792.68	7791.34	7793.36	0.004495	6.73	240.98	59.61	0.57
Happy Meadows	117	500-yr	2331.00	7788.91	7793.64	7792.19	7794.61	0.004725	7.91	301.30	63.53	0.61
Happy Meadows	116	anin	28.00	7785.59	7788.81	7786.33	7788.84	0.002023	1.21	23.18	39.07	0.28
Happy Meadows	116	1-yr	156.00	7785.59	7787.75		7787.82	0.002489	2.21	70.44	56.05	0.36
Happy Meadows	116	2-yr	422.00	7785.59	7788.71		7788.89	0.002857	3.36	125.72	59.88	0.41
Happy Meadows	116	5 yr	654.00	7785.59	7789.26		7789.52	0.003184	4.12	160.13	65.53	0.44

HEC-RAS Plan: Plan 01 River: South Platte Reach: Happy Meadows (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Happy Meadows	118	10-yr	842.00	7785.59	7789.63		7789.97	0.003359	4.63	185.02	67.65	0.47
Happy Meadows	118	50-yr	1347.00	7785.59	7790.45		7790.95	0.003796	5.77	241.81	72.21	0.52
Happy Meadows	118	100 yr	1606.00	7785.59	7790.79		7791.39	0.004005	6.27	267.07	74.56	0.54
Happy Meadows	116	500-yr	2331.00	7785.59	7791.60	7790.26	7792.44	0.004545	7.51	329.96	81.62	0.59
Happy Meadows	115	min	28.00	7784.06	7784.60	7784.60	7784.76	0.035547	3.13	8.93	28.67	0.99
Happy Meadows	115	1-yr	156.00	7784.06	7785.36	7785.25	7785.68	0.018098	4.53	34.47	42.97	0.89
Happy Meadows	115	2-yr	422.00	7784.06	7786.15	7786.03	7786.59	0.015758	5.37	78.62	68.10	0.88
Happy Meadows	115	5 yr	654.00	7784.06	7786.58	7786.43	7787.13	0.014429	5.96	109.73	75.28	0.87
Happy Meadows	115	10-yr	842.00	7784.06	7786.84	7786.68	7787.49	0.014138	6.50	129.58	76.38	0.88
Happy Meadows	115	50-yr	1347.00	7784.06	7787.48	7787.29	7788.34	0.013126	7.42	181.60	83.06	0.88
Happy Meadows	115	100 yr	1606.00	7784.06	7787.76	7787.56	7788.72	0.012818	7.84	205.22	87.24	0.88
Happy Meadows	115	500-yr	2331.00	7784.06	7788.45	7788.24	7789.65	0.011467	8.81	270.69	102.56	0.88
Happy Meadows	114	min	28.00	7779.69	7780.97	7780.39	7780.99	0.001184	0.96	29.10	46.07	0.21
Happy Meadows	114	1-yr	156.00	7779.69	7781.77		7781.84	0.002623	2.02	77.40	76.02	0.35
Happy Meadows	114	2-yr	422.00	7779.69	7782.65		7782.77	0.002730	2.78	151.54	88.59	0.38
Happy Meadows	114	5 yr	654.00	7779.69	7783.17		7783.34	0.002772	3.28	199.29	92.84	0.39
Happy Meadows	114	10-yr	842.00	7779.69	7783.54		7783.75	0.002739	3.61	234.22	95.51	0.40
Happy Meadows	114	50-yr	1347.00	7779.69	7784.39		7784.68	0.002689	4.31	318.58	107.26	0.41
Happy Meadows	114	100 yr	1606.00	7779.69	7784.76		7785.08	0.002687	4.61	358.54	110.55	0.42
Happy Meadows	114	500-yr	2331.00	7779.69	7785.85		7786.08	0.002688	5.30	460.87	118.24	0.43
Happy Meadows	113	min	28.00	7778.93	7779.52	7779.52	7779.63	0.033853	2.72	10.29	44.14	0.99
Happy Meadows	113	1-yr	156.00	7778.93	7780.40		7780.50	0.004379	2.51	62.15	64.64	0.45
Happy Meadows	113	2-yr	422.00	7778.93	7781.48		7781.62	0.002982	2.98	141.75	84.83	0.41
Happy Meadows	113	5 yr	654.00	7778.93	7782.09		7782.27	0.002585	3.38	193.69	88.76	0.40
Happy Meadows	113	10-yr	842.00	7778.93	7782.50		7782.71	0.002458	3.68	229.70	91.00	0.40
Happy Meadows	113	50-yr	1347.00	7778.93	7783.40		7783.68	0.002281	4.31	329.96	124.41	0.40
Happy Meadows	113	100 yr	1606.00	7778.93	7783.80		7784.11	0.002201	4.54	380.01	128.72	0.40
Happy Meadows	113	500-yr	2331.00	7778.93	7784.75		7785.12	0.002066	5.07	518.10	156.25	0.40
Happy Meadows	112	min	28.00	7778.69	7778.78	7777.47	7778.79	0.000281	0.62	45.35	49.28	0.11
Happy Meadows	112	1-yr	156.00	7778.69	7779.65	7778.37	7779.69	0.000975	1.64	95.38	80.75	0.23
Happy Meadows	112	2-yr	422.00	7778.69	7780.53	7779.22	7780.65	0.001709	2.80	150.67	84.87	0.32
Happy Meadows	112	5 yr	654.00	7778.69	7781.07	7779.82	7781.26	0.002088	3.51	186.71	89.58	0.37
Happy Meadows	112	10-yr	842.00	7778.69	7781.41	7779.89	7781.66	0.002371	4.03	211.06	78.37	0.40
Happy Meadows	112	50-yr	1347.00	7778.69	7782.16	7780.58	7782.56	0.002875	5.13	273.52	88.04	0.46
Happy Meadows	112	100 yr	1606.00	7778.69	7782.50	7780.92	7782.97	0.003048	5.58	303.91	93.12	0.48
Happy Meadows	112	500-yr	2331.00	7778.69	7783.30	7781.73	7783.95	0.003400	6.62	384.57	106.82	0.52
Happy Meadows	111	min	28.00	7777.95	7778.80	7778.42	7778.83	0.004784	1.33	20.99	60.48	0.40
Happy Meadows	111	1-yr	156.00	7777.95	7779.27		7779.31	0.004483	2.30	67.74	81.87	0.45
Happy Meadows	111	2-yr	422.00	7777.95	7779.96		7780.11	0.004242	3.25	129.86	89.56	0.48
Happy Meadows	111	5 yr	654.00	7777.95	7780.44		7780.66	0.004105	3.74	175.08	95.90	0.49
Happy Meadows	111	10-yr	842.00	7777.95	7780.76		7781.02	0.004005	4.19	206.01	100.20	0.49
Happy Meadows	111	50-yr	1347.00	7777.95	7781.50		7781.86	0.003751	4.84	283.86	109.19	0.50
Happy Meadows	111	100 yr	1606.00	7777.95	7781.85		7782.25	0.003634	5.13	322.62	118.03	0.50
Happy Meadows	111	500-yr	2331.00	7777.95	7782.71		7783.20	0.003328	5.75	439.97	157.50	0.50
Happy Meadows	110	min	28.00	7774.34	7775.82	7775.60	7775.87	0.008014	1.82	15.42	39.18	0.51
Happy Meadows	110	1-yr	156.00	7774.34	7776.47	7776.20	7776.62	0.008009	3.10	50.38	58.10	0.59
Happy Meadows	110	2-yr	422.00	7774.34	7777.20	7776.78	7777.51	0.007992	4.49	94.03	62.39	0.64
Happy Meadows	110	5 yr	654.00	7774.34	7777.68	7777.21	7778.10	0.008014	5.19	126.26	67.92	0.67
Happy Meadows	110	10-yr	842.00	7774.34	7777.99	7777.49	7778.50	0.008004	5.73	147.67	70.72	0.68
Happy Meadows	110	50-yr	1347.00	7774.34	7778.69	7778.12	7779.42	0.007999	6.90	198.26	73.16	0.72
Happy Meadows	110	100 yr	1606.00	7774.34	7779.00	7778.43	7779.84	0.008011	7.40	221.38	74.28	0.73
Happy Meadows	110	500-yr	2331.00	7774.34	7779.79	7779.14	7780.90	0.008002	8.55	281.08	78.38	0.75

Legend
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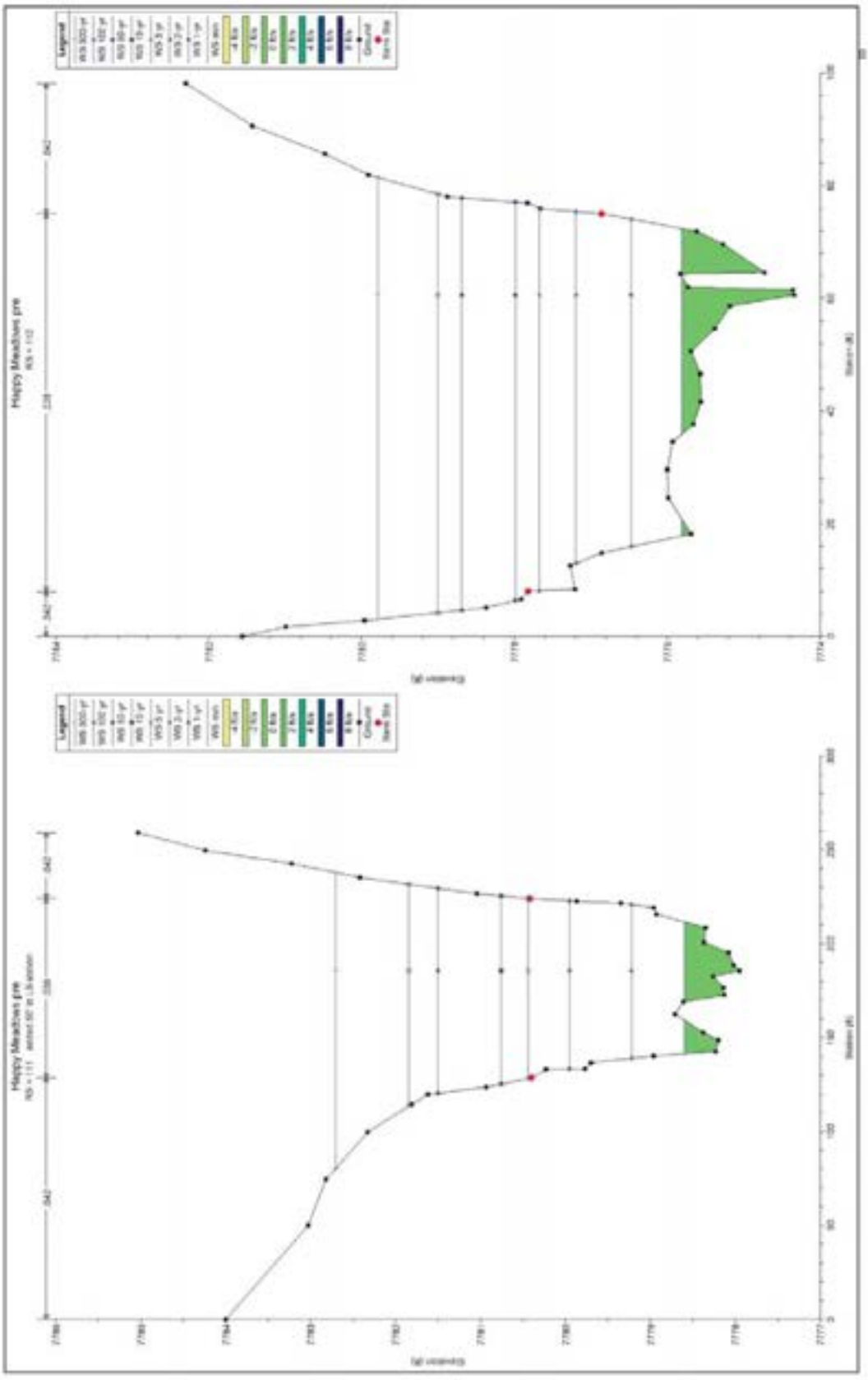
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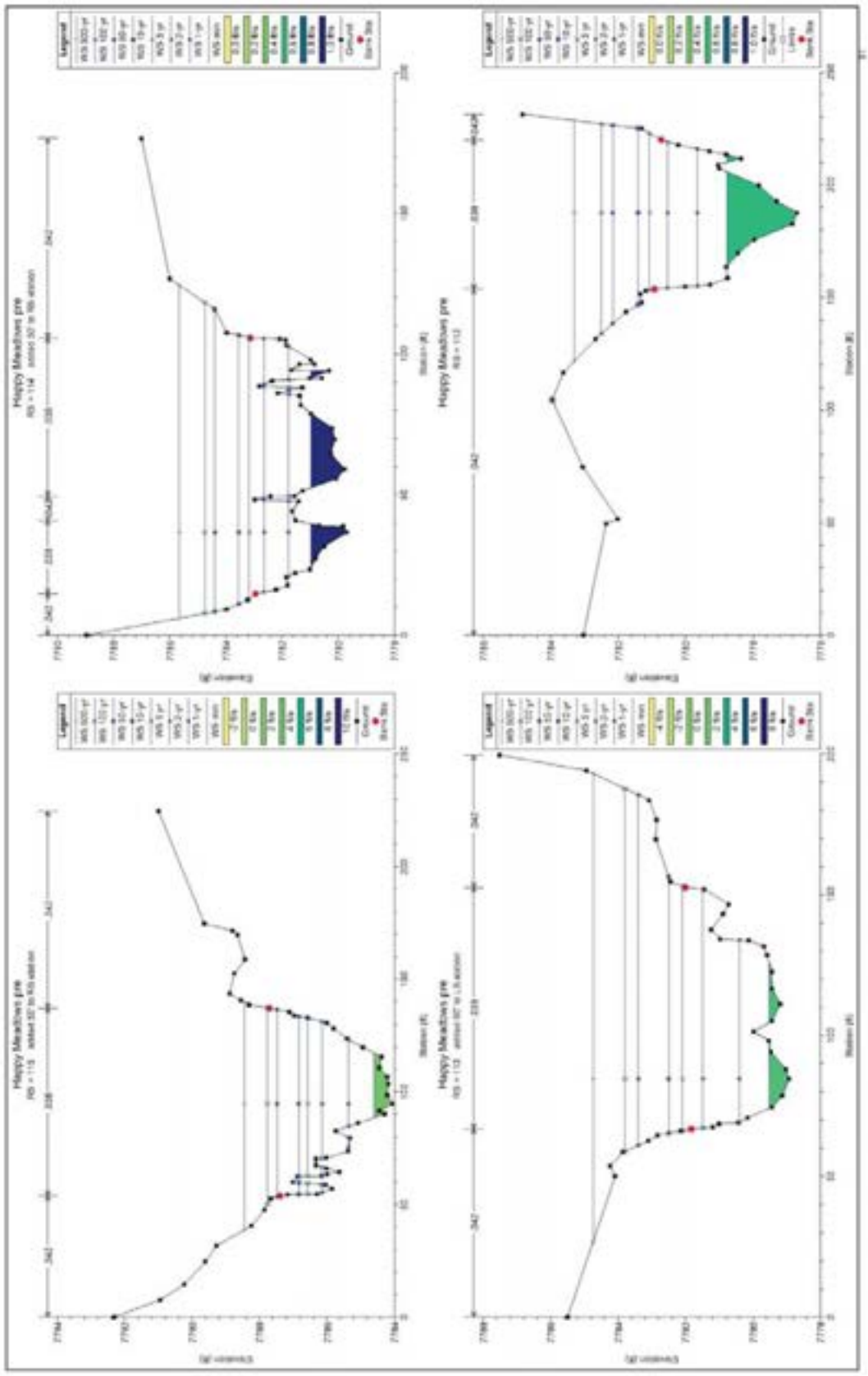
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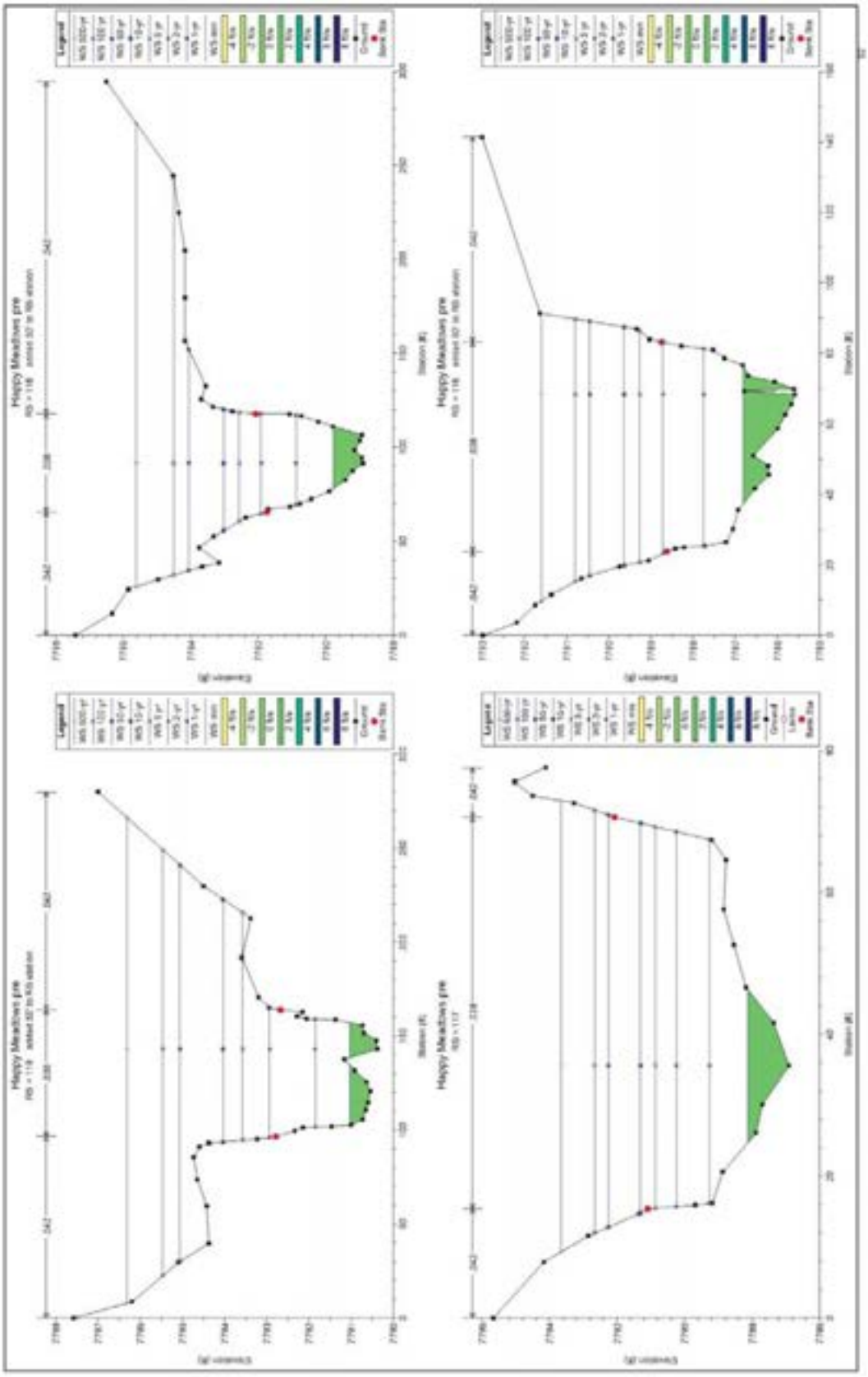
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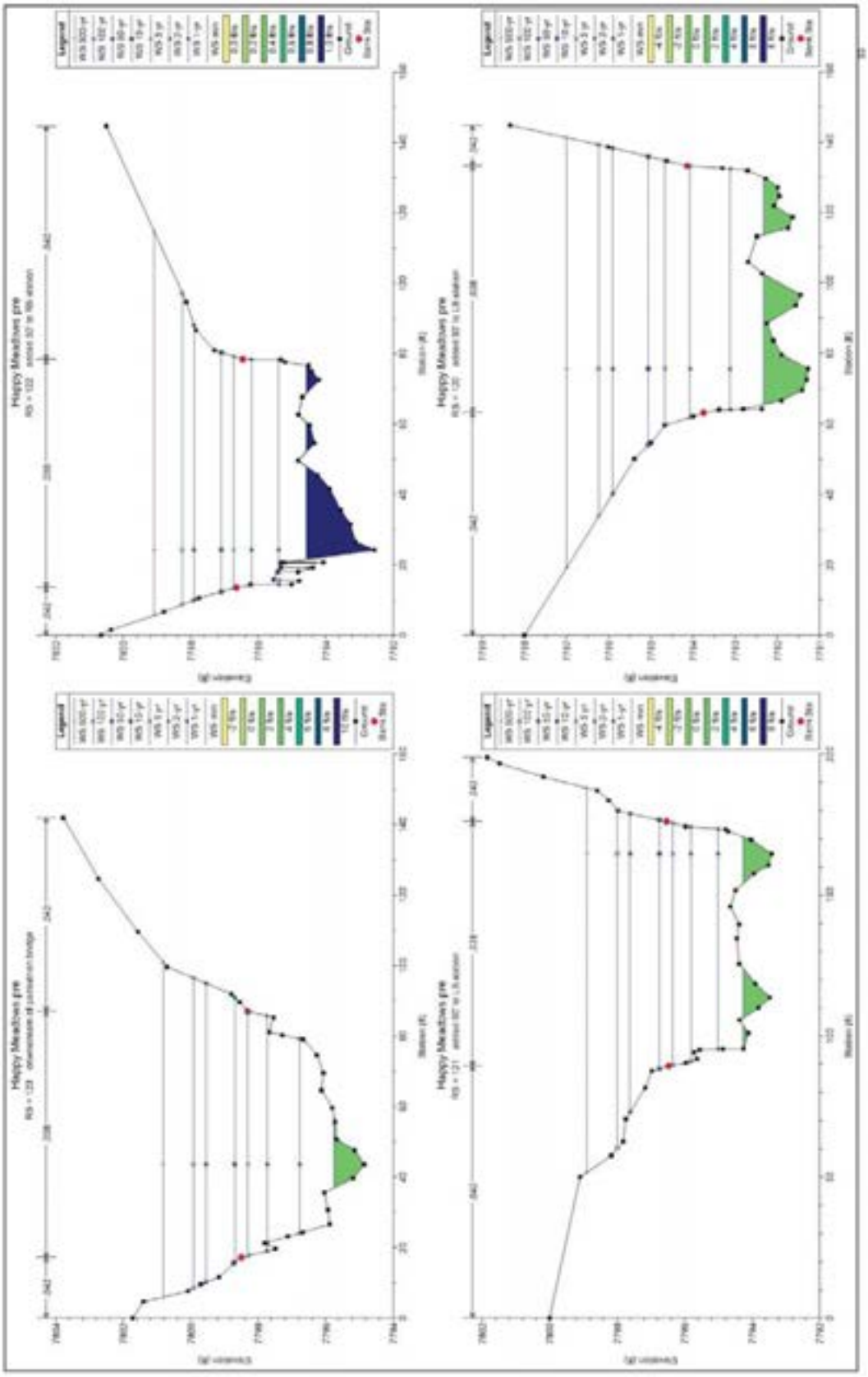
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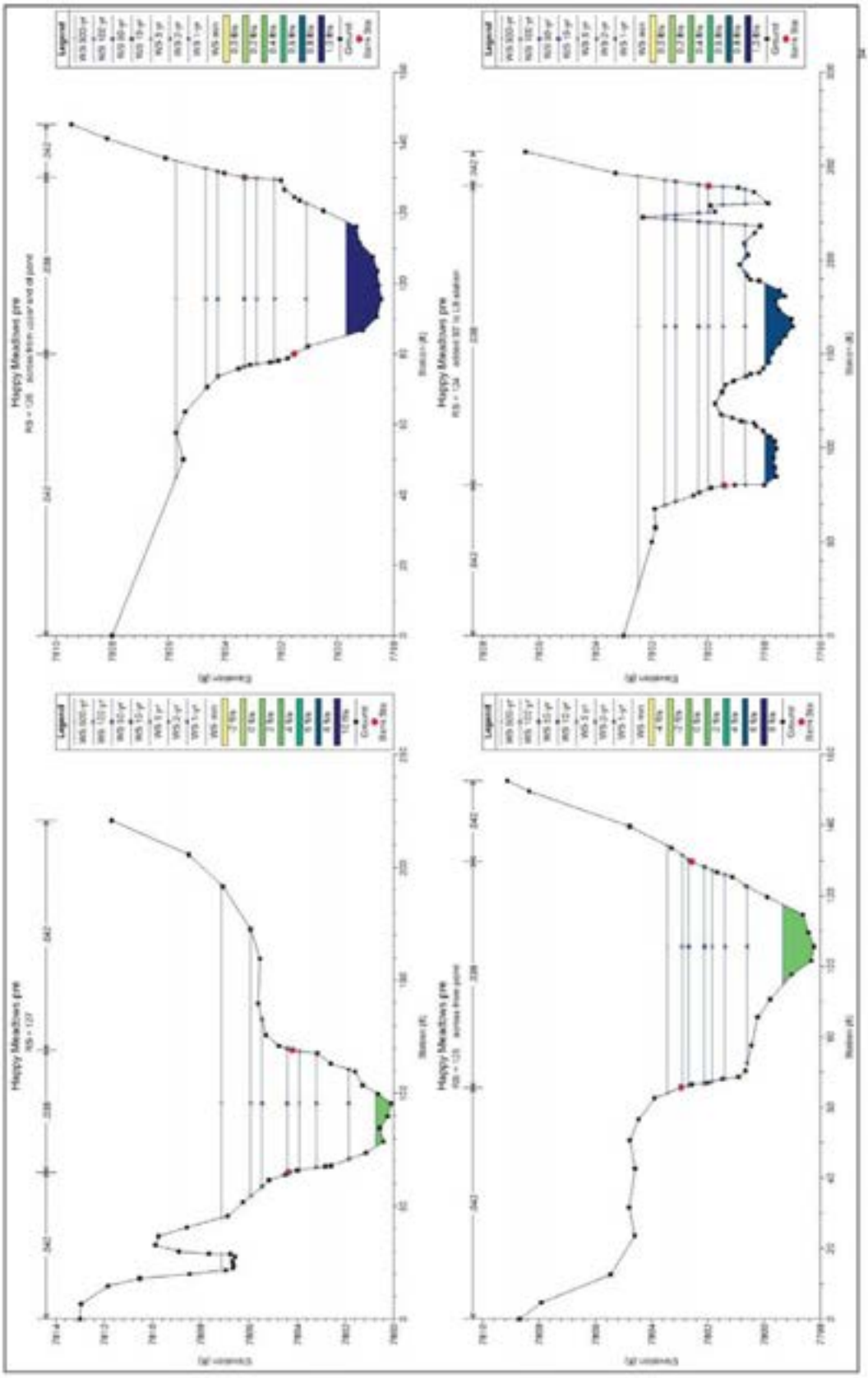
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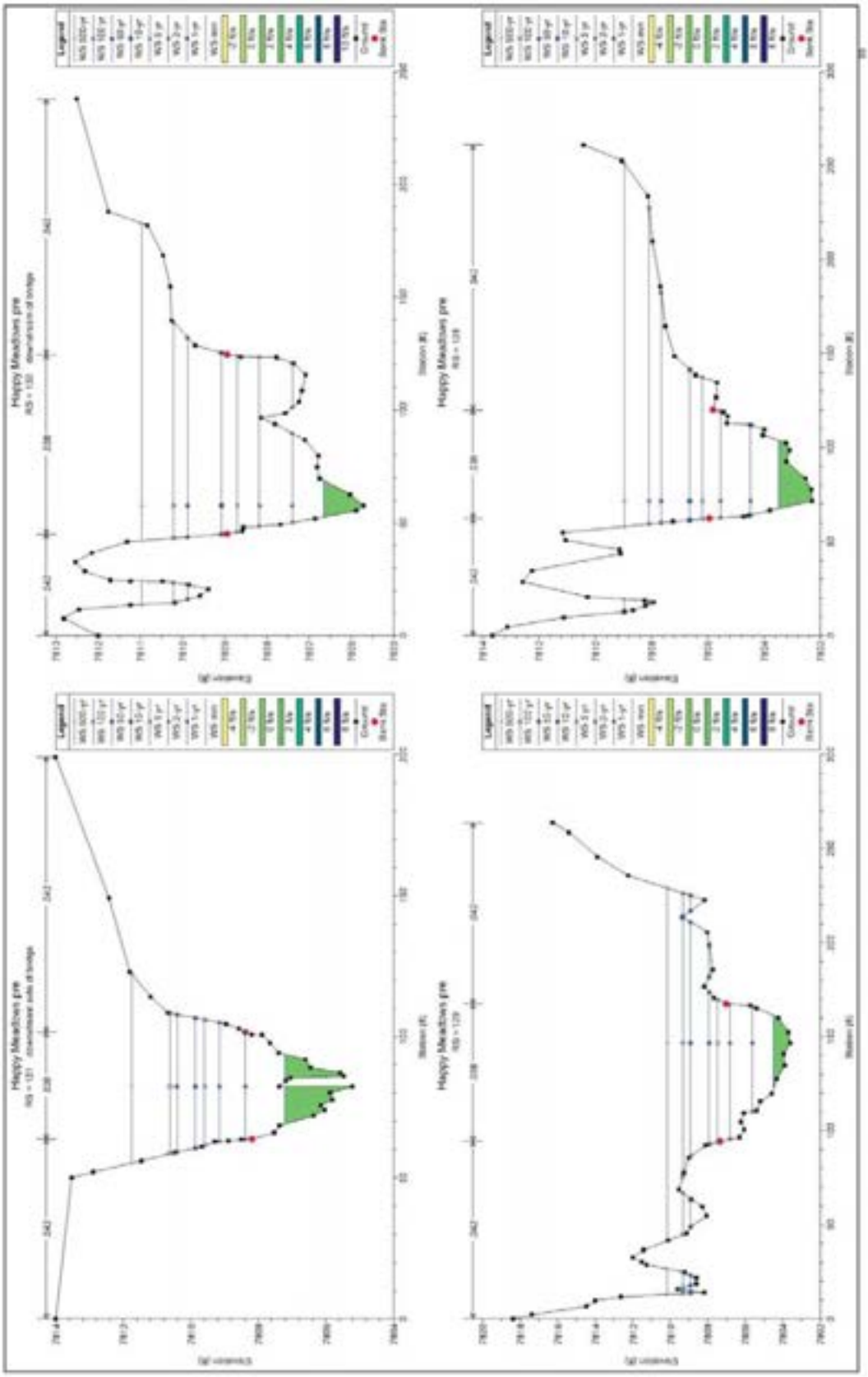
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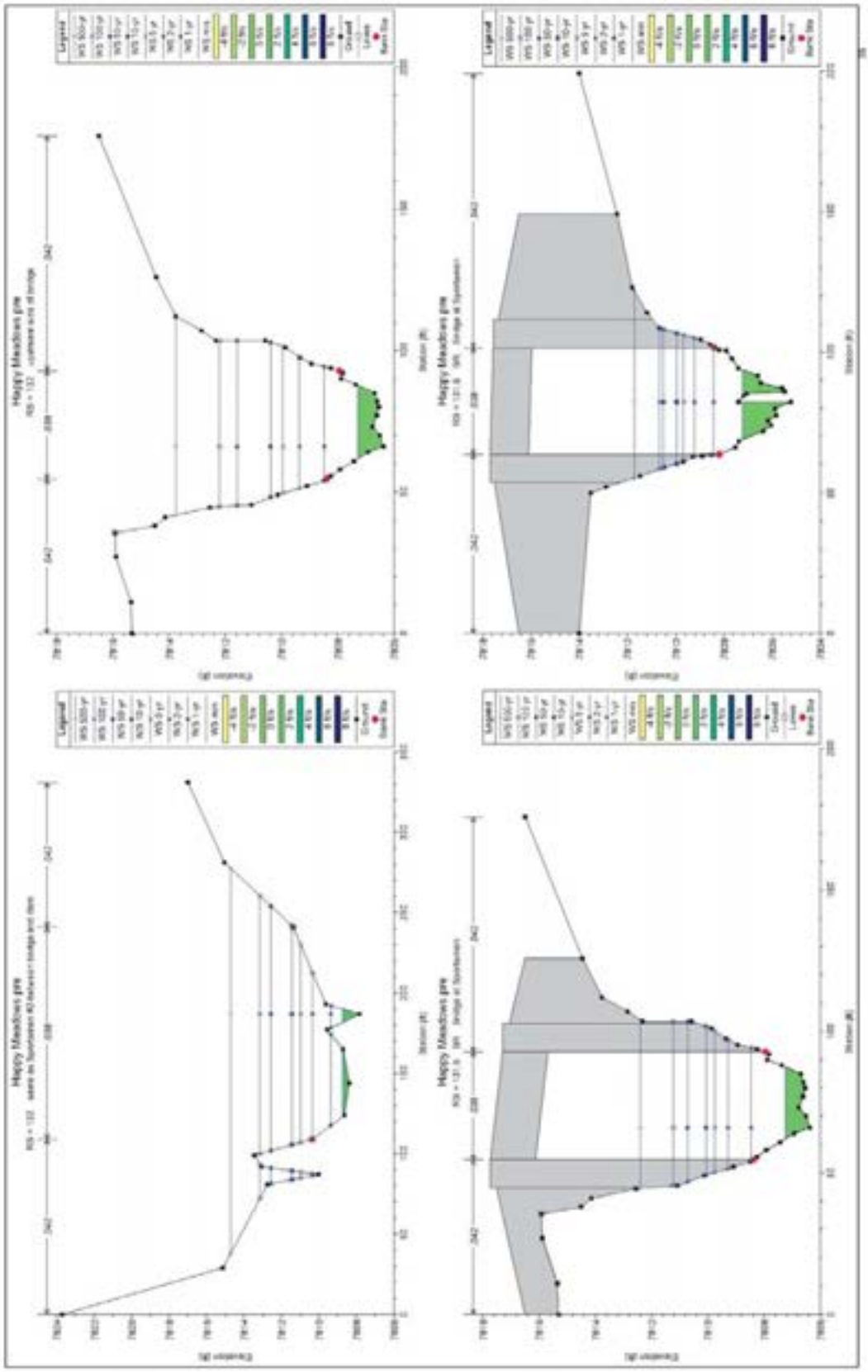

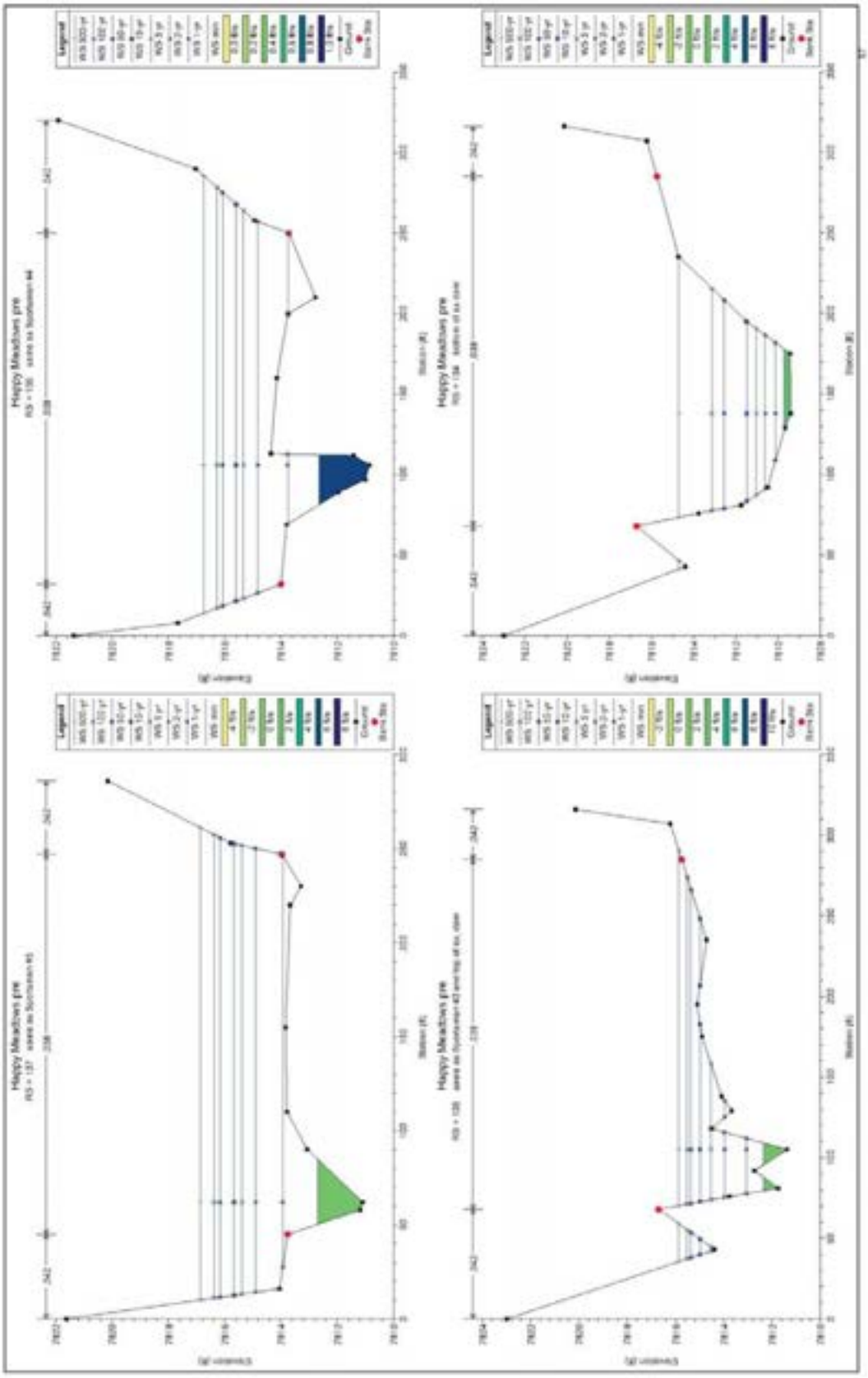
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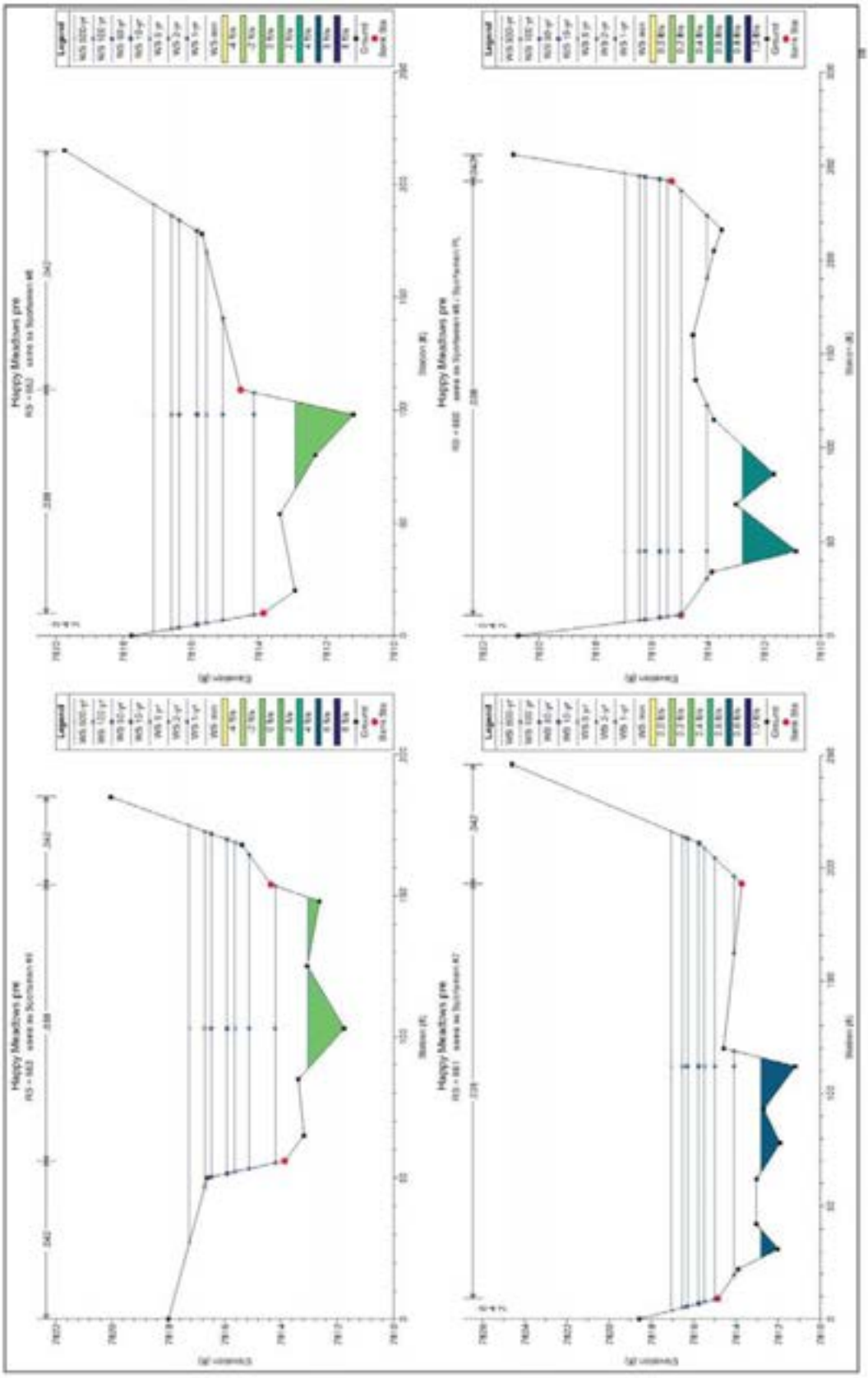

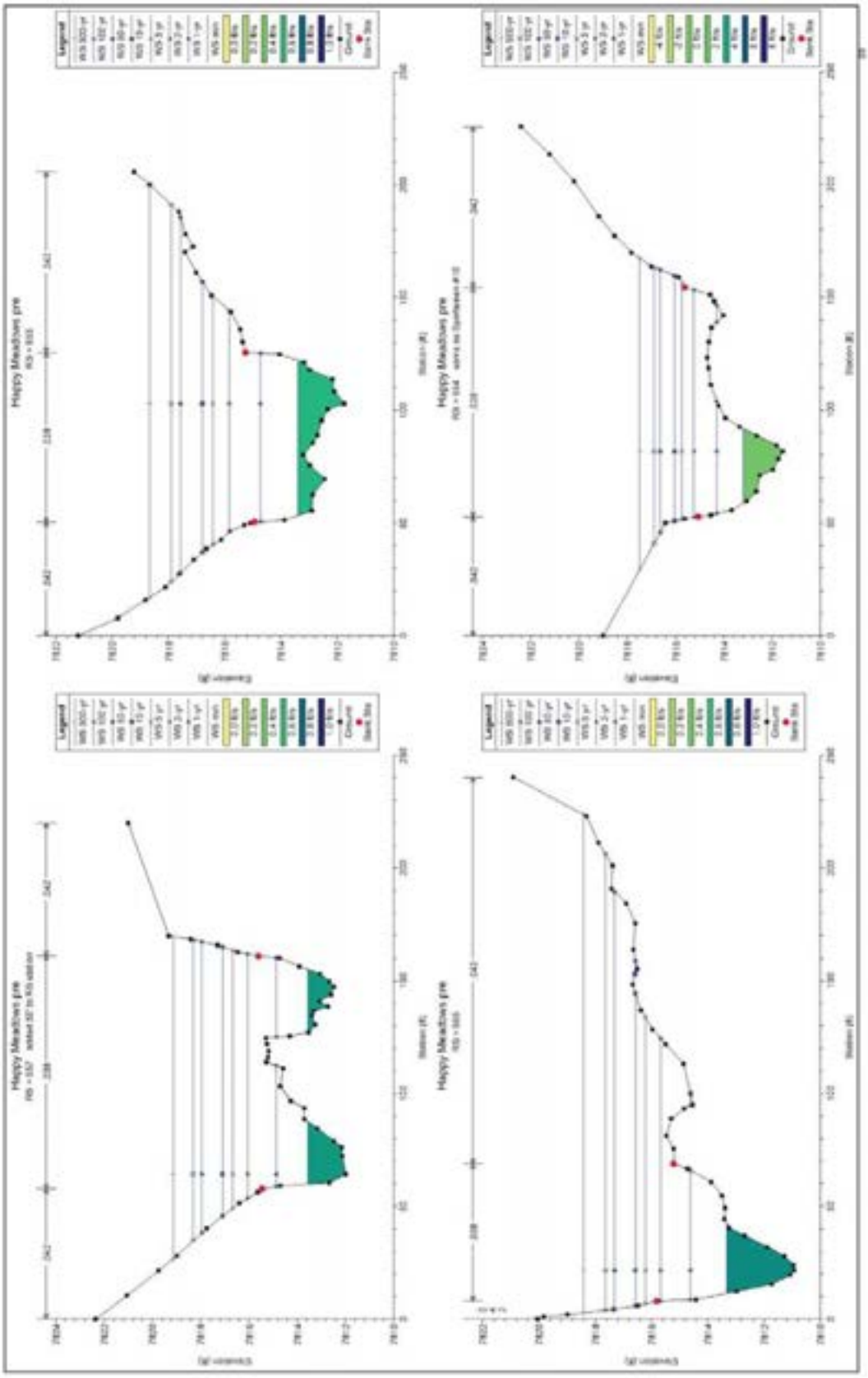
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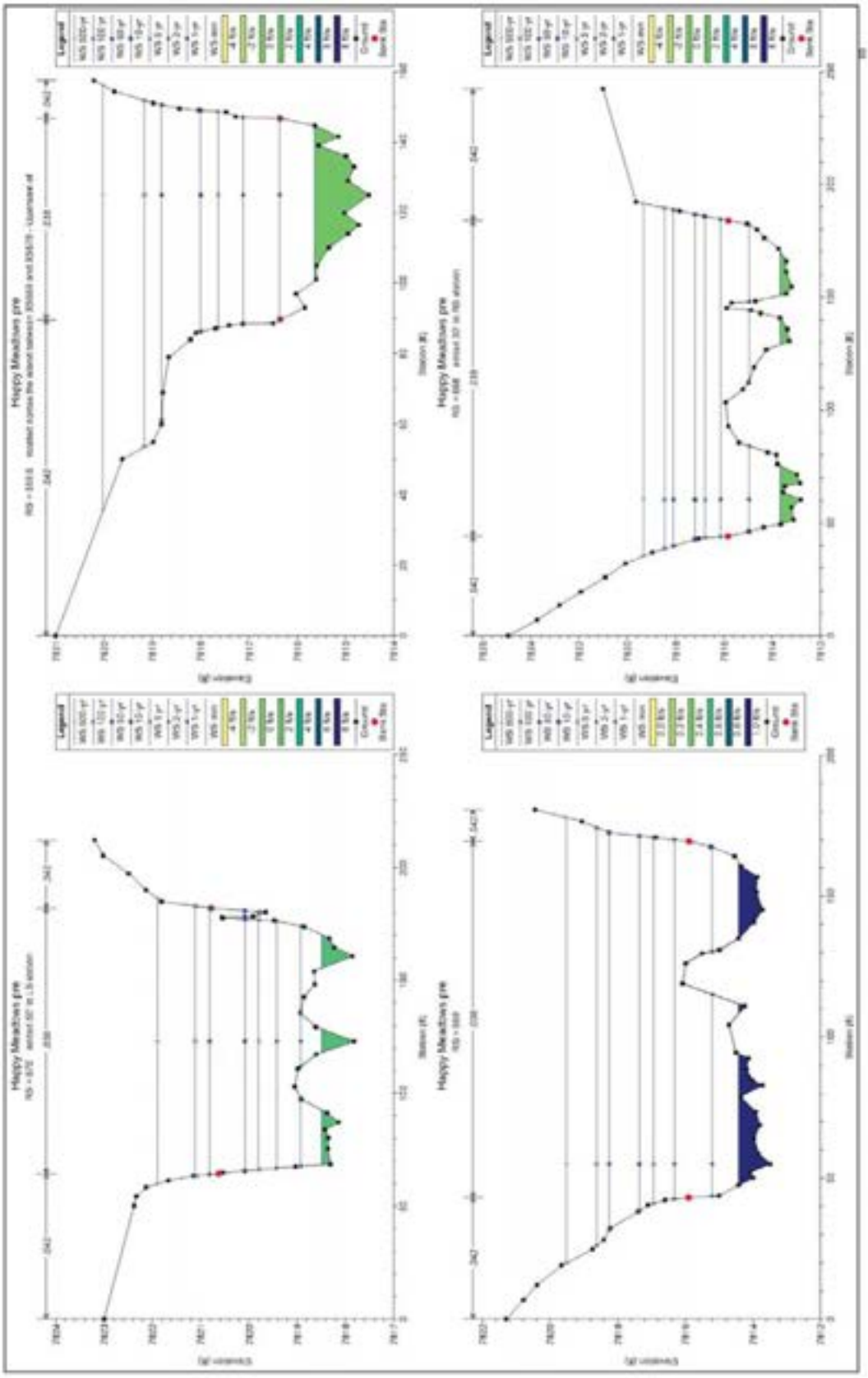
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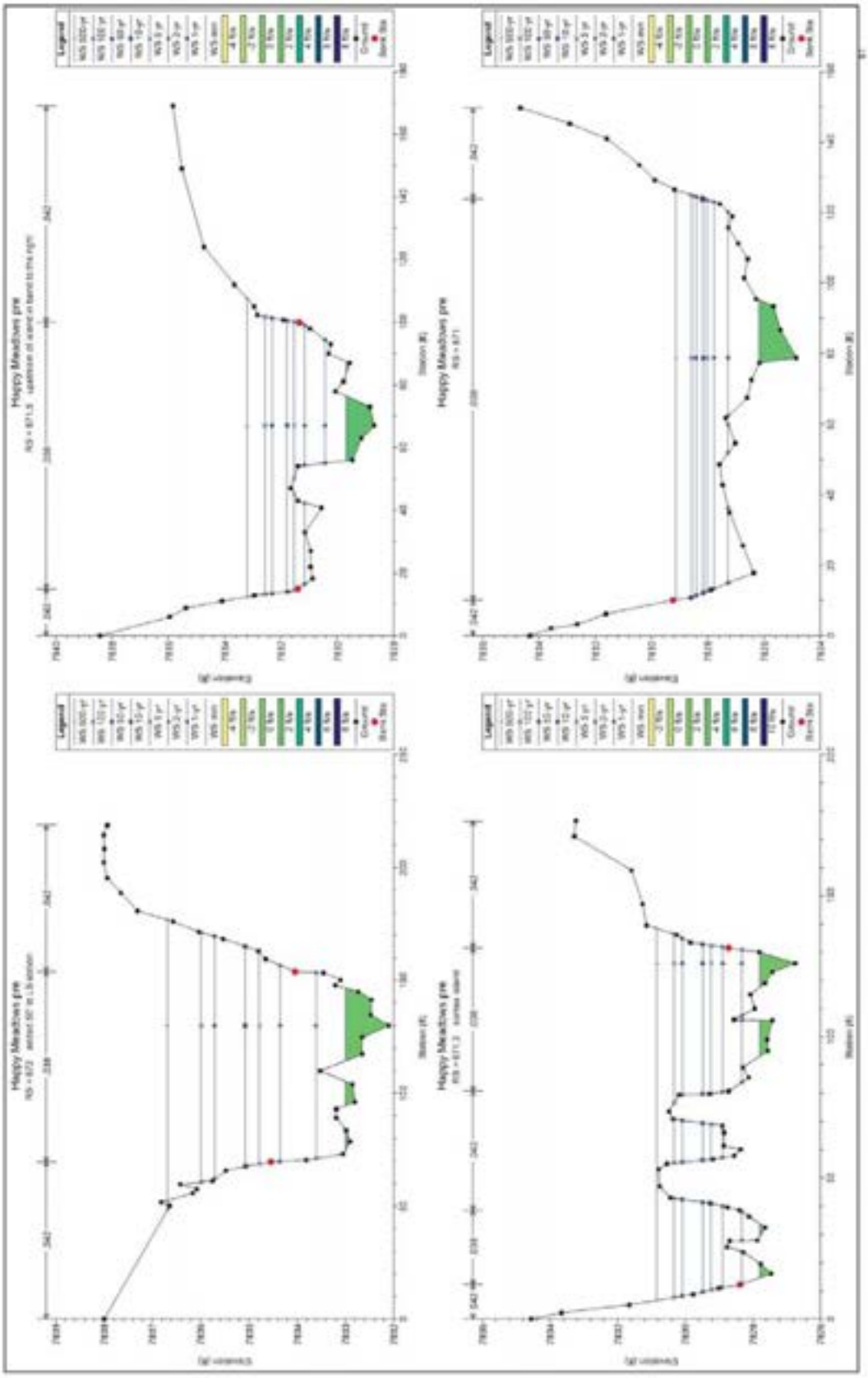
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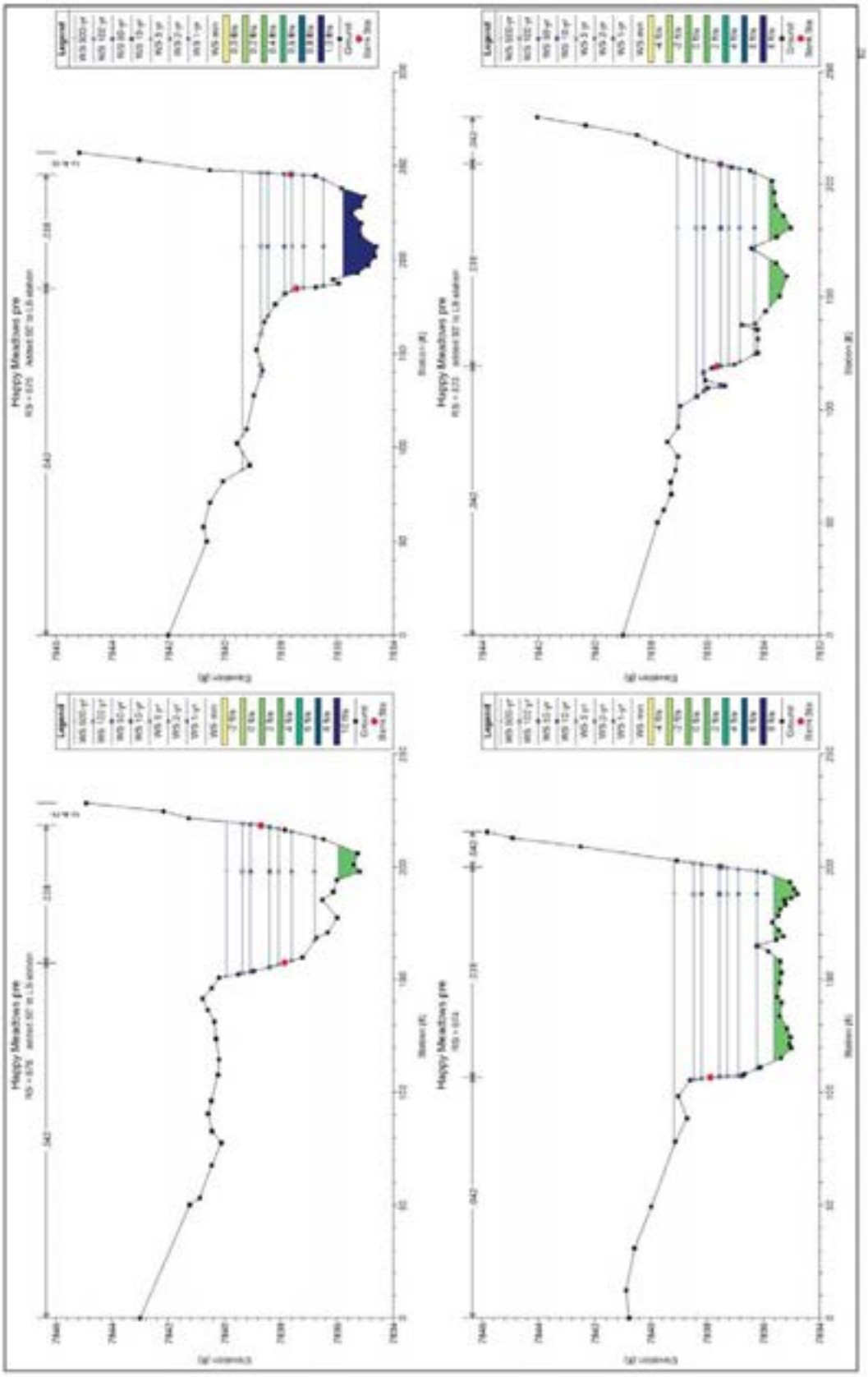
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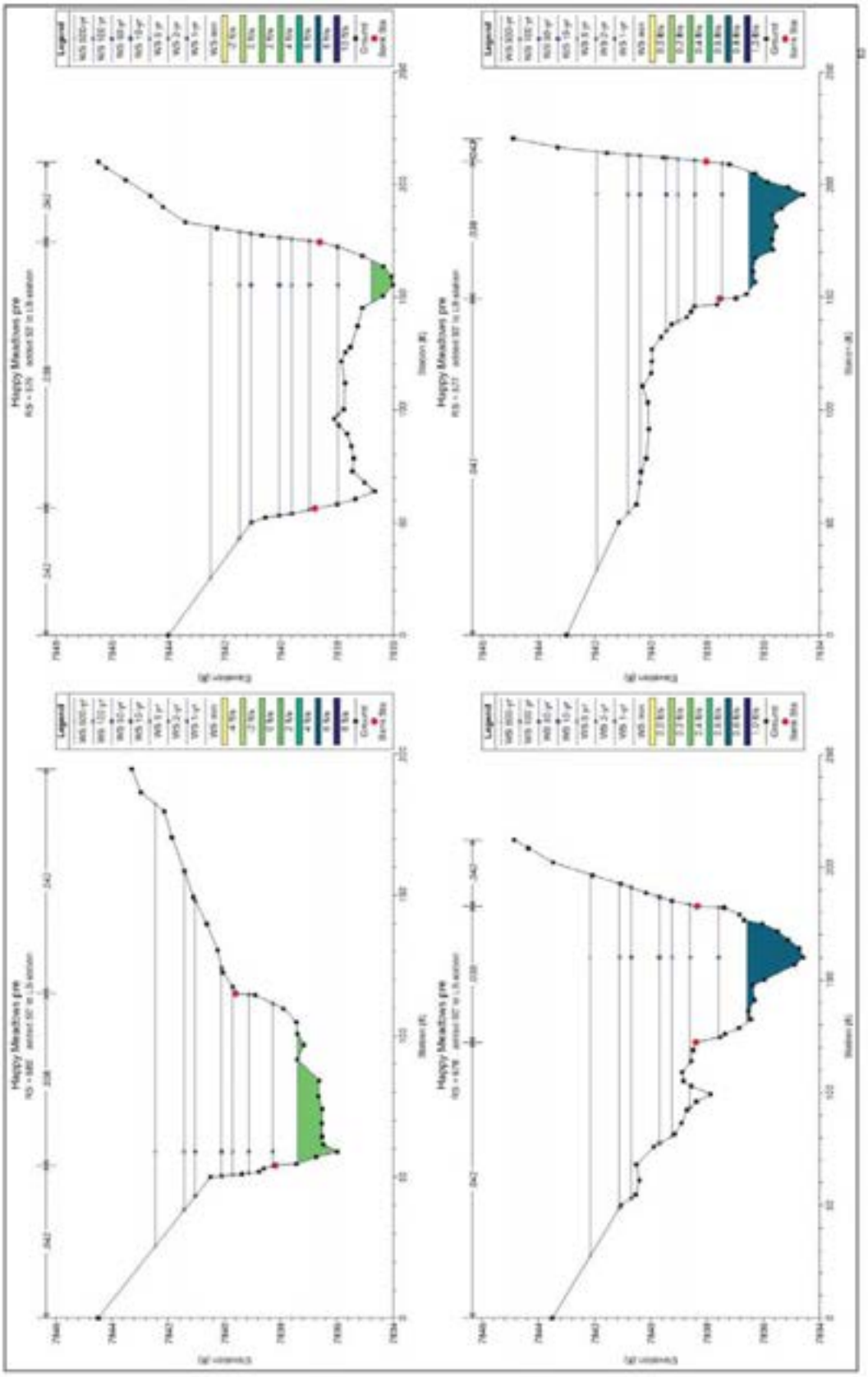
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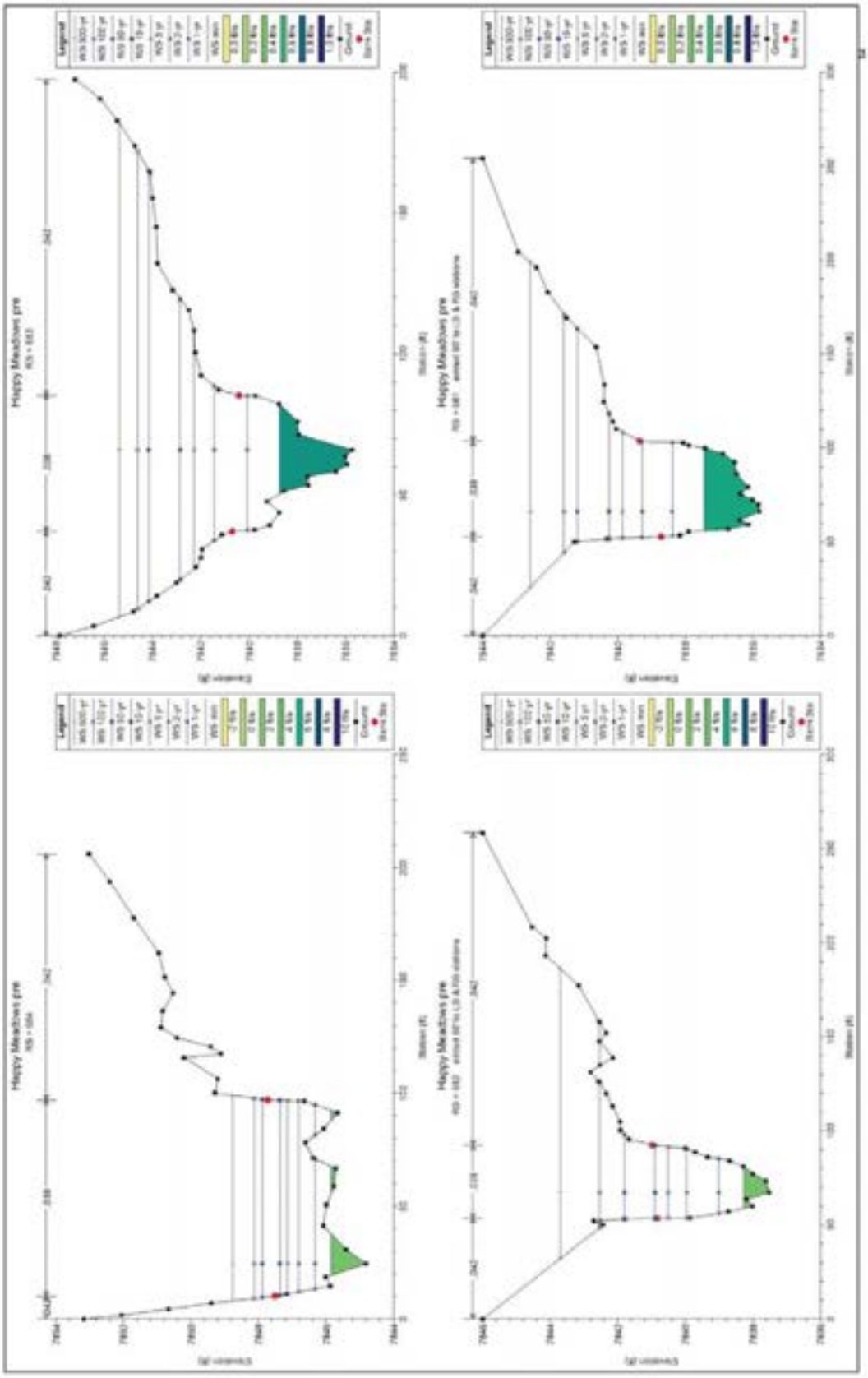
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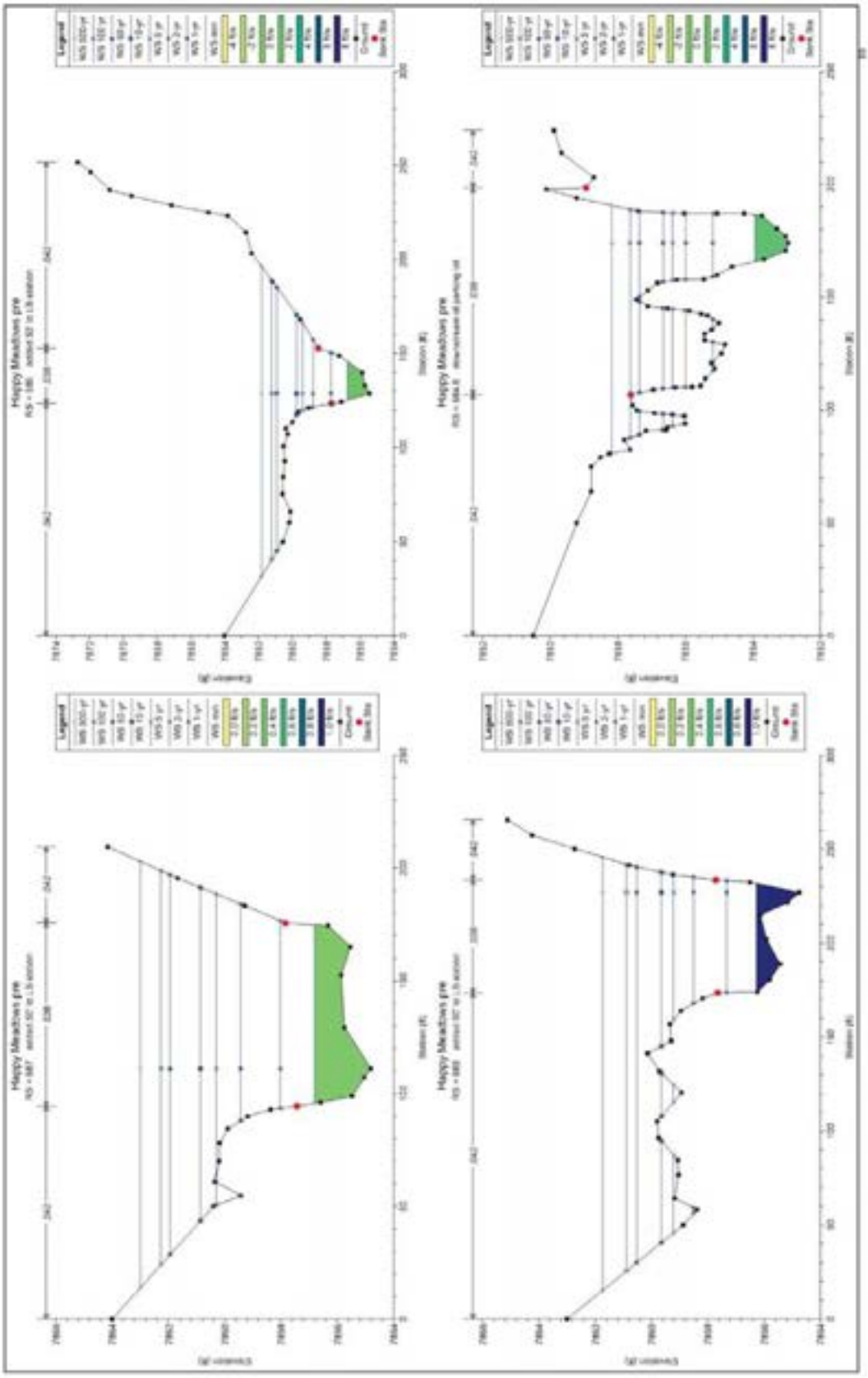
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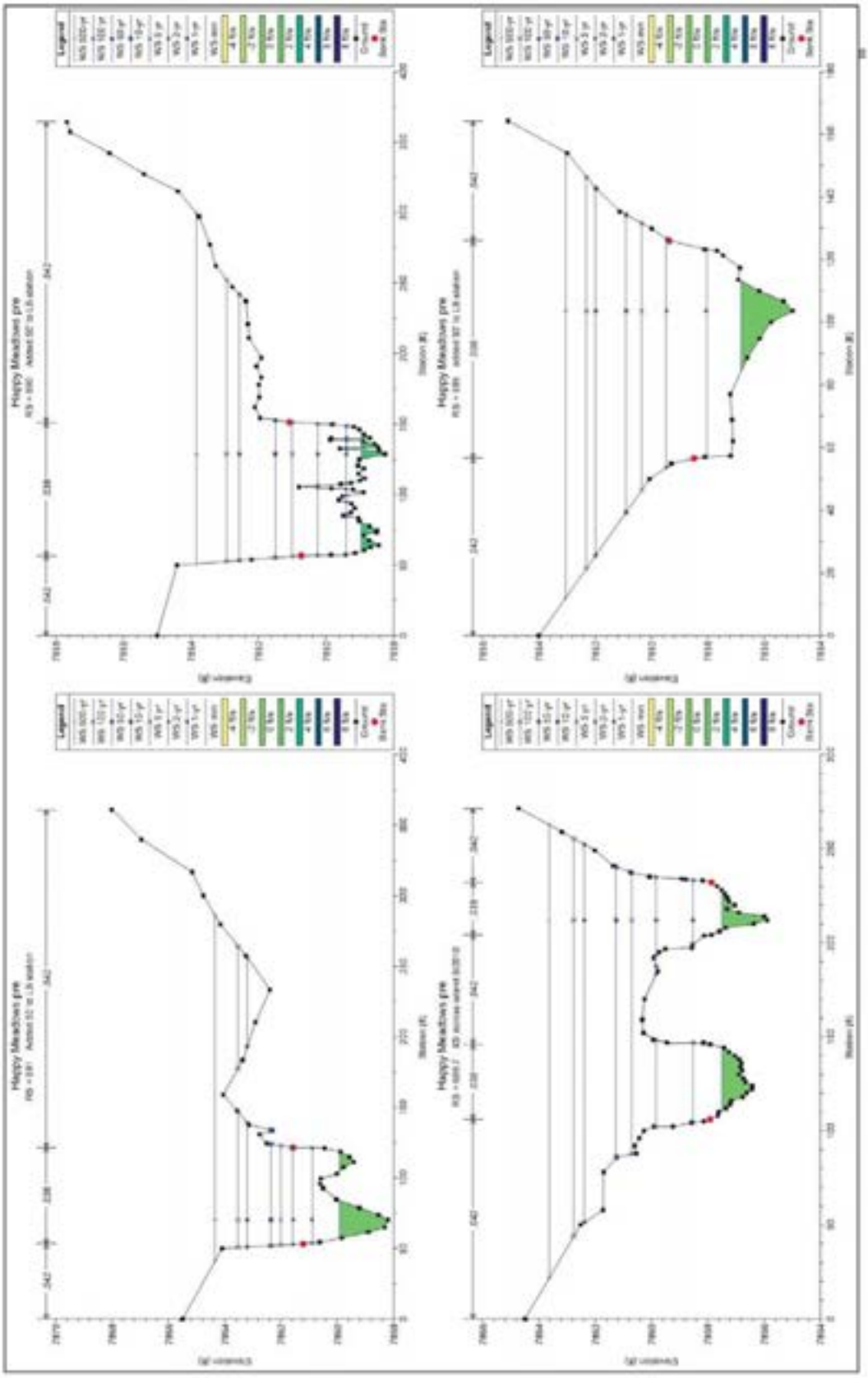
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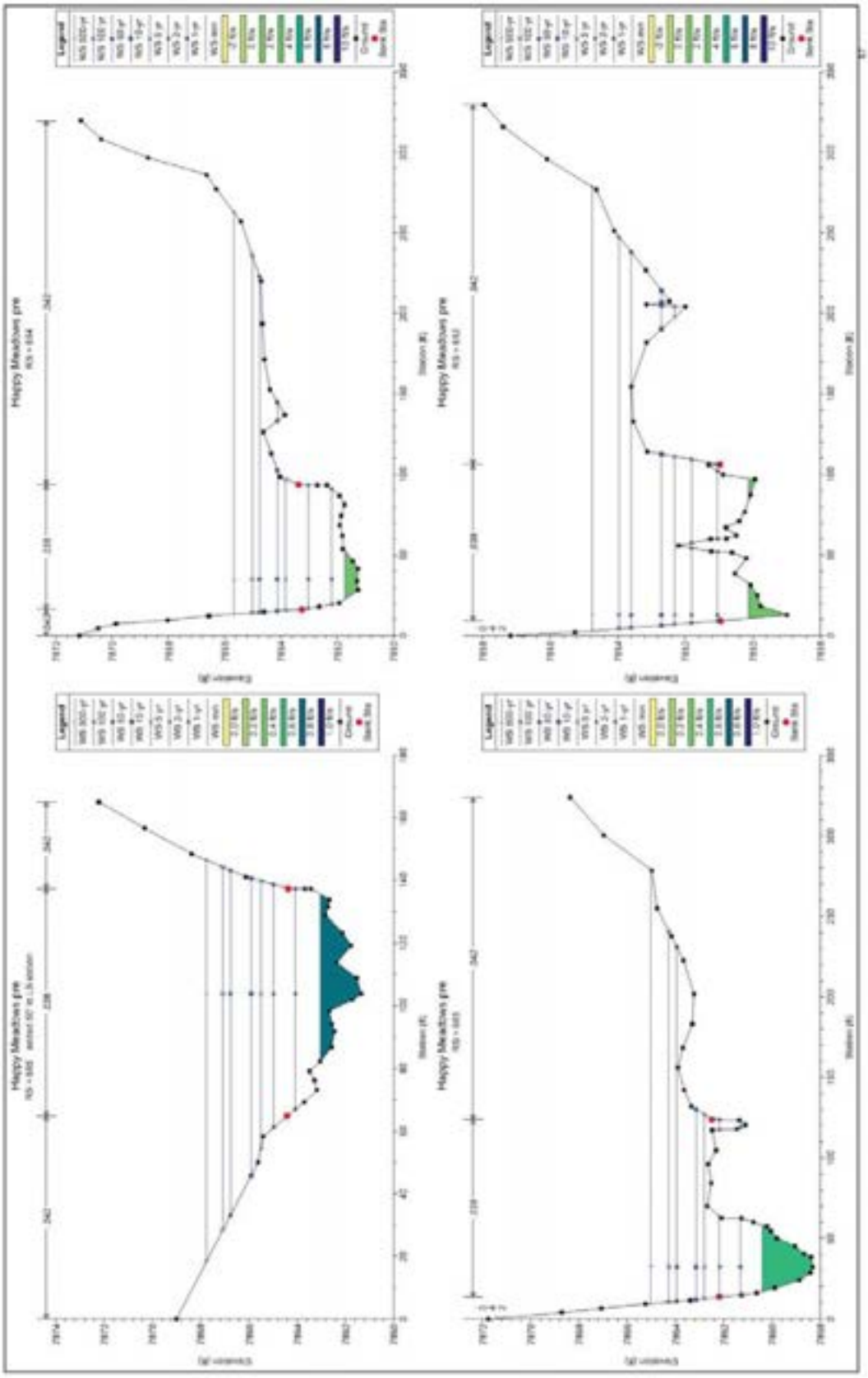
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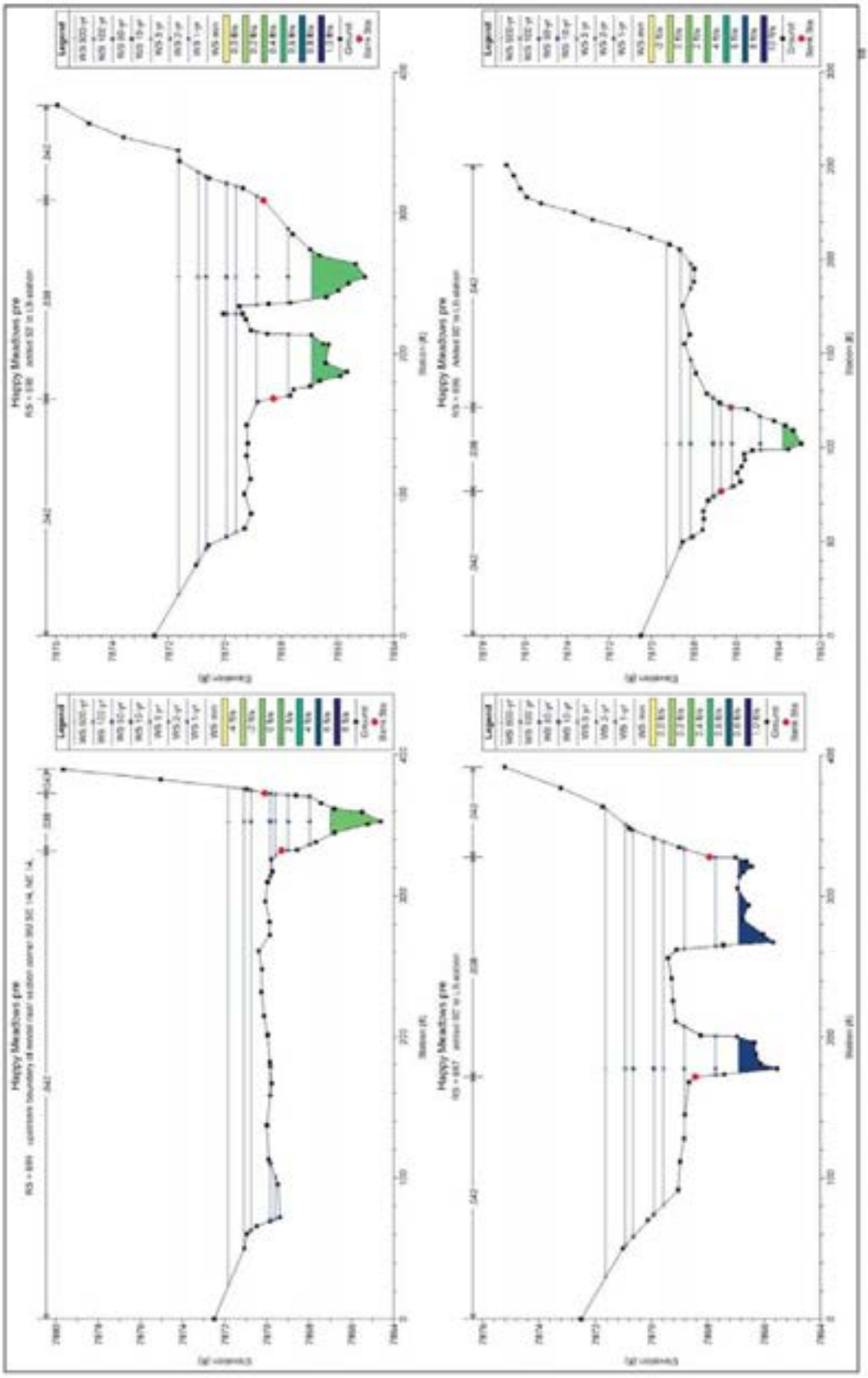
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Aggrading

The deposition of material by a stream.

Related Glossary Terms

Drag related terms here

Index Find Term

Benthic

The flora and fauna found on the edges, bottom, or in the bottom sedim
sea, lake, or other body of water. Includes many insects that trout deper
part of their food supply.

Related Glossary Terms

Drag related terms here

Index Find Term

Chapter 1 - Background

Benthic Zone

The area where benthic organisms reside. It is the lowest level of a body
It is inhabited mostly by organisms that tolerate cool temperatures and
gen levels.

Related Glossary Terms

Drag related terms here

Index Find Term

Cascade

A meso-habitat type. Cascades are the steepest riffle habitat types, in te
dient, in streams. These riffles consist of alternating small waterfalls an
pools. These habitats may appear to have the characteristics of a Step-p
tem. Cascades are characterized by swift current flows and often have e
rocks and boulders above the water surface, which creates considerable
lence and surface agitation. The substrate normally found in cascades is
or accumulations of boulders.

Related Glossary Terms

Drag related terms here

Index Find Term

Cover

Locations where fish prefer to rest, hide and feed are called cover. Cove
visually isolate fish, which increases the number of territories in the sar
Additionally, cover can create areas of reduced velocities providing criti
and feeding stations for fish. The amount of cover available in a stream
ence the production of a number of fish and invertebrate species.

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Cross Vane

A structure spanning the entire width of the channel, constructed of lar
ders and/or large wood, that provides vertical stability, increased scour
stage upstream, and reduced stream power. This structure type is comm
as a diversion structure for irrigation ditches, as well as for treating acti
cutting and head cuts in the stream channel

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Embeddedness

The degree to which the interstitial spaces between larger substrate par
filled with finer sediments. Embeddedness tends to armor the substrate
iting available habitat for benthic dwelling macroinvertebrates and spaw
tat for salmonids.

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Glide

A meso-habitat type. Glides are those portions of streams which have re
wide uniform bottoms, low to moderate velocity flows, lack pronounced
lence, and have substrates usually consisting of either cobble, gravel or
Glides are usually described as stream habitat with characteristics inter
between those of pools and riffles. These habitats are commonly found
sition between a pool and the head of a riffle, however they are occasion
in low gradient stream reaches with stable banks and no major flow obs

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Head Cut

An area of active down-cutting in the channel where a river or stream is
down to a new, lower flood plain.

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Intermittent

An intermittent stream is one that only flows for part of the year.

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Lotic

Of, relating to, or living in moving water such as streams and rivers.

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Meso Habitat

A channel scale habitat form. Typically a pool, riffle, rapid, cascade or g
tat. A meso-habitat occupies the entire width of the stream channel, and
exceptions (most notably plunge pools in high gradient step-pool syster
least as long as the channel is wide.

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Micro Habitat

Micro habitats are small, site specific habitats within a meso-habitat for
may include spawning redds, in-stream or overhead cover, and velocity

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Micro Vortex

A small rock cluster structure that replicates pocket water habitat in riff
and cascades.

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Over-wintering Habitat

Areas of a stream or water body exhibiting depths that may sustain a po
through the winter months.

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Perennial

A perennial stream is one that flows year round.

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Pocket Water

A micro-habitat type. Pocket water habitats are typically found in highe
riffles, rapids, and cascades with large cobble, boulder, and large woody
These pocket water habitats provide small areas for velocity shelter and
within these fast-water habitat forms.

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Pool

A meso-habitat type. Pools are channel segments exhibiting areas of sc
deposition where the water is deeper and slower moving.

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Primary Producer

Primary producers are those organisms in an ecosystem that produce b
from inorganic compounds. In almost all cases these are photosynthetic
organisms.

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Rapid

A meso-habitat type. Rapids are riffles associated with high gradients (g
than 4%) with swiftly flowing (greater than 1.5 ft/sec), moderately deep
highly turbulent waters. These riffles are generally associated with boul
strates, which protrude through the surface of the water.

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Redds

The egg sacks fish have laid that stay on the bottom of the river until yo
year hatch, or the hollow in the bottom of the river that a trout makes ir
lay its eggs.

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Residual Pool Depth (RPD)

Residual pool depth is estimated as the depth of water which would be r
a pool under highly reduced flows or the stoppage of flows in the stream
area of pools would be utilized by fish in low flow conditions. Residual p
would also provide habitat for overwintering of fish when ice buildup re
movement in riffles or glides between pools. Residual pool depth is calc
locating and measuring the greatest depth of the pool at the riffle crest (
point of the downstream boundary cross-section of the pool), and subtr
value from the greatest measured depth of the pool habitat. The differen
these measurements is described as the RPD. RPD may be difficult to d
in some habitats, particularly dam pools with woody debris structural a
tions. In many of these habitat units, the RPD may actually be a very lo
zero due to water flowing through these debris dams.

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Riffle

A meso-habitat type. Riffles are those areas of the stream in which turbu
the water column is the major identifying characteristic, as a result of re
high gradients. These units contain moderately deep to shallow, swift fl
ter, and are characterized by boulder or cobble substrates. Riffles are ve
tant for macroinvertebrate production, due to the availability of light ar
and the corresponding vegetative growth on the bottom substrate. The
riffles, including low sediment deposition and resulting embeddedness
direct impact on fish populations. The cleaner and healthier the vegetat
and benthic macroinvertebrate community, the more food there is for t
population.

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Salmonids

Salmonidae is a family of ray-finned fish, the only family of order Salmo
It includes the well-known salmons and trouts; the Atlantic salmons an
genus Salmo give the family and order their names.

Subfamily - Salmoninae
Brachymystax - lenoks
Oncorhynchus - Pacific salmon and trout
Salmo - Atlantic salmon and trout
Salvelinus - Char and trout (Brook trout, Lake trout)

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Substrate

Stream substrate (sediment) is the material that rests at the bottom of a

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Thermal Refugia

Micro habitats found in streams and lakes that provide thermal protect
cold water species such as trout. These may include shaded areas, cool v
springs, and deep water habitats.

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Toe Slope

The foot, or bottom, of the sloping bank of a stream. This is the area of t
sheer stress and erosion potential on a stream bank, and is typically the
failure leading to mass wasting and collapse.

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