RUBY RIVER RVHA RESTORATION PROJECT

Madison County, Montana

April 2021

PREPARED FOR:

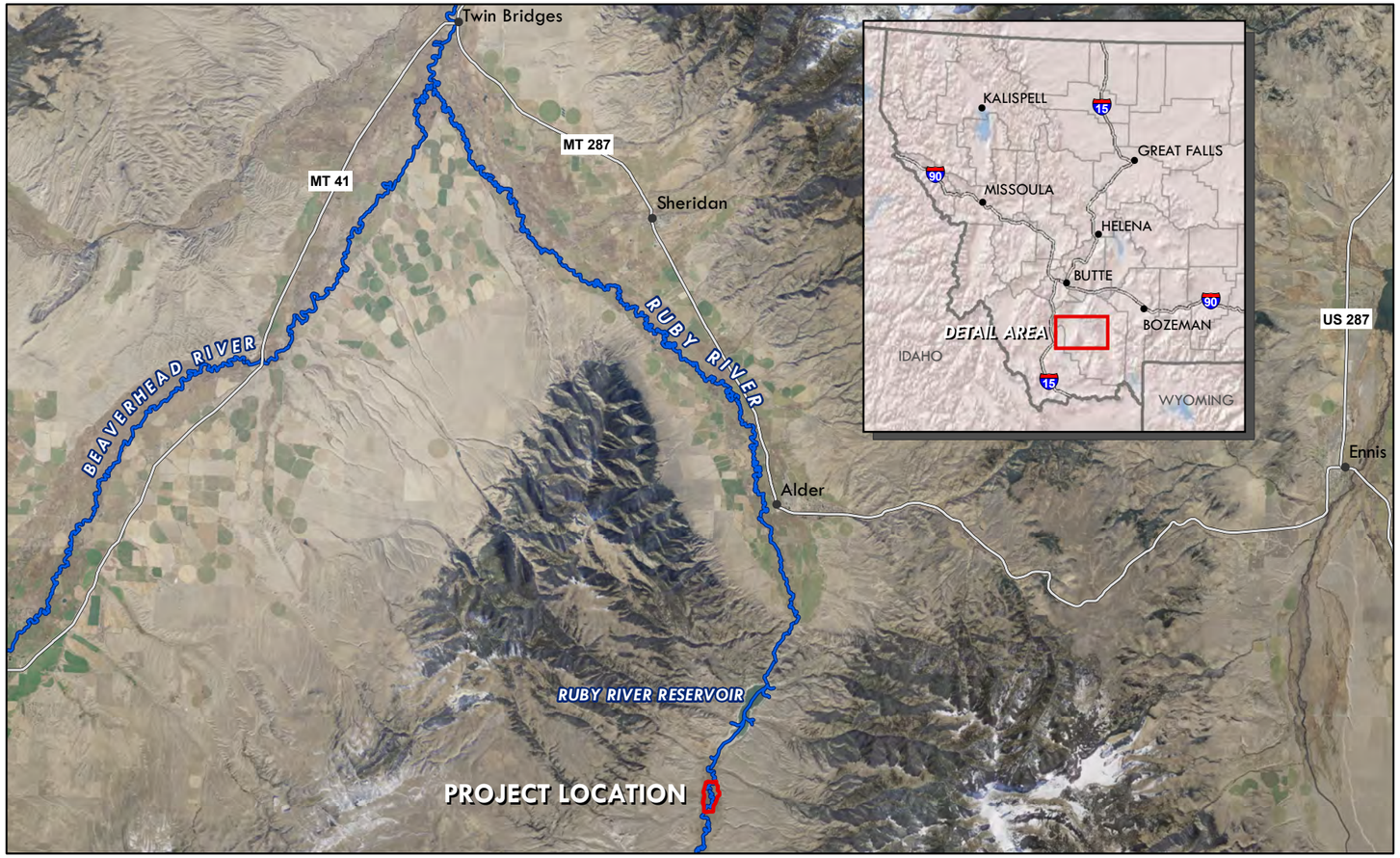
Ruby Valley Hydroelectric Authority

PREPARED BY:

Geum Environmental Consulting, Inc.
307 State Street
Hamilton, Montana 59840
(406) 363-2353

Applied Geomorphology, Inc.
211 North Grand Suite C
Bozeman, Montana 59715
(406) 587-6352

Gillilan Associates, Inc.
29805 U.S. Hwy 24
Suite A #123
Buena Vista, CO 81211
(406) 582-0660



PROJECT DESCRIPTION

The Ruby River watershed is located in southwest Montana. The Ruby River is a tributary to the Beaverhead River and enters the Beaverhead at Twin Bridges, Montana. It originates on the Beaverhead National Forest between the Snowcrest and Gravelly Mountain Ranges. The Ruby River flows in a northerly direction for approximately 76 miles. The Ruby River RVHA Restoration Project includes a 2.2 mile long reach of the Ruby River upstream of the Ruby River Reservoir. The RVHA section of the Ruby River is located in Township 7 South, Range 4 West, Sections 30 and 31.

Prior to the General Land Office Survey of 1871, the Ruby River probably supported a mosaic of wetlands and floodplains that were supported by beaver activity. Beaver were trapped out of this region by the mid-1800s, followed by intense livestock grazing and conversion of floodplains to pasture and agricultural land. These actions resulted in concentration of flows into a single channel, vertical erosion of the river bed, and accelerated erosion of streambanks resulting in an over-widened channel, a perched floodplain and degraded aquatic habitat.

In 2017, Applied Geomorphology Inc. and Gillian Associates were asked to evaluate the geomorphic history of the Ruby River, and to provide practical restoration alternatives to help address historic impacts, improve ecological function, and provide for long-term site resiliency of the river and floodplain within the RVHA property.

SHEET INDEX

geum Environmental Consulting
307 STATE ST
HAMILTON, MT 59840
406.363.2353
geumconsulting.com

DATUM: North American Datum 1983

PROJECTION: Montana State Plane

UNIT: US Foot

DATA SOURCES:
USDA NAIP Imagery, 2017
ESRI Terrain Basemap
NHD Streams
MSL Roads, Towns, Borders

COVER SHEET

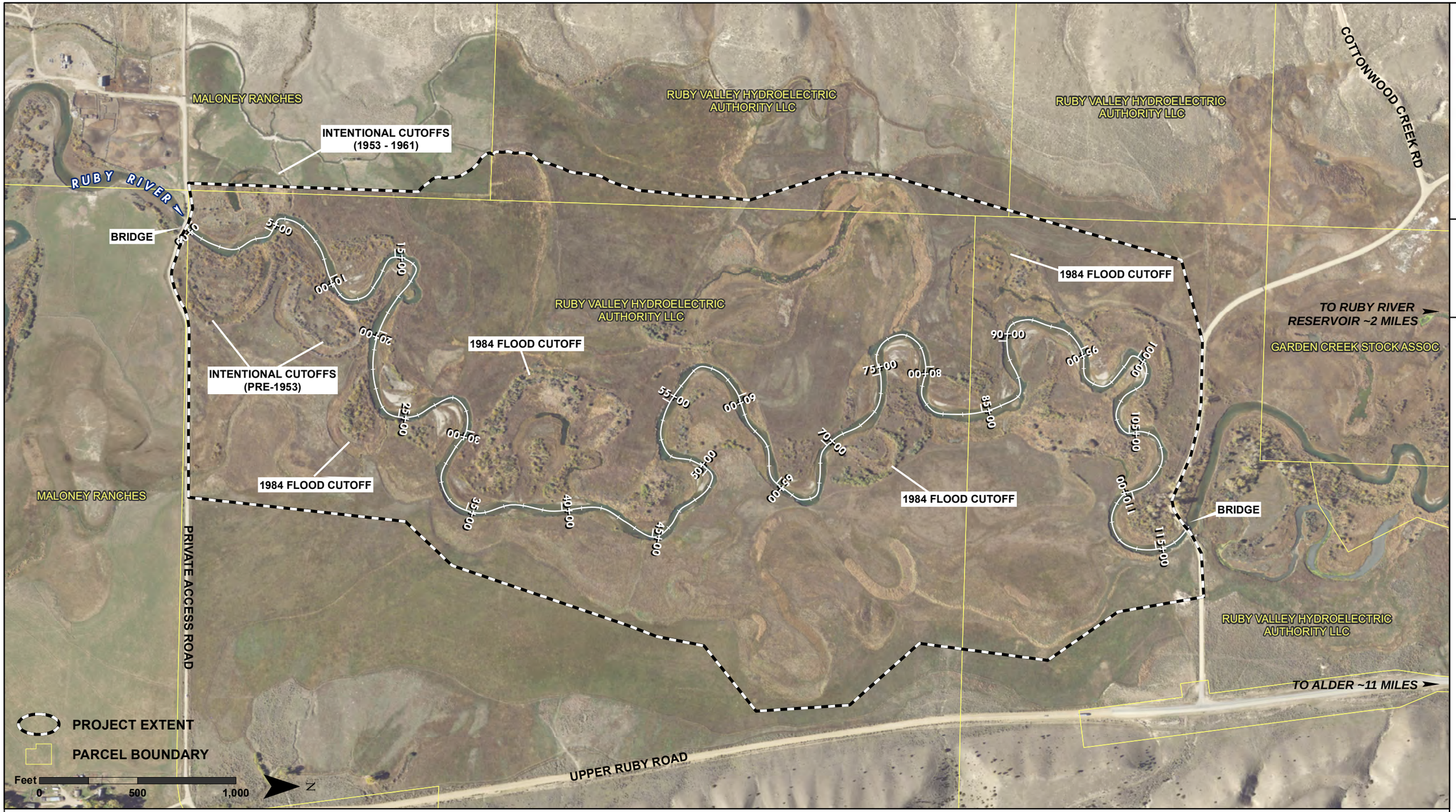
RUBY RIVER RVHA RESTORATION PROJECT
MADISON COUNTY, MONTANA

DRAWN BY: J. Wallace

DESIGNED BY: Geum, AGI, Gillilan

DATE: April 2021

SHEET
1.0



The Ruby River has been subject to significant human induced changes over the last 200 years. Beaver trapping, livestock grazing, conversion of floodplains and riparian areas to agriculture, irrigation, and infrastructure have all significantly changed the natural dynamics and overall ecological function of the river and floodplain. As part of floodplain development, at least three meanders were intentionally cut off. Past changes have resulted in a channel with high bank erosion that is too large to allow average flows to leave the channel. The loss of floodplain connectivity has resulted in a stressed and degraded riparian corridor with limited establishment of new woody riparian vegetation, little woody riparian vegetation along streambanks, and a predominance of introduced agricultural grasses in the floodplain. These changes have resulted in low resiliency of the system to high flow events. During the 1984 flood, more meanders cut off, and the channel widened. The meander cutoffs shortened and locally steepened the river. Since the 1984 flood event, the channel has been regaining its lost length through bank erosion. However, bank erosion primarily occurs in areas where cover of woody riparian vegetation is low due to both land uses and channel incision, resulting in high erosion rates. Both degraded channel and riparian conditions have resulted in aquatic habitat dominated by riffles and shallow runs with very few high-quality pools. High erosion rates also increase the amount of fine sediment entering the river, further reducing the quality of instream habitat.

Even with these impacts, the RVHA property has excellent restoration potential, due to the preservation of several channel remnants that are low enough to still support healthy riparian vegetation and are feasible to reconnect. Restoration efforts at the site will serve to improve the riparian corridor, increase stream shade, reduce stream temperatures, and reduce sediment loading into Ruby Reservoir. As the Upper Ruby River was listed by Montana Department of Environmental Quality as impaired due to excessive sediment loads, restoration work would be in concert with overall goals stated in the Ruby Watershed Restoration Plan (Montana DEQ, 2015).

The main factors limiting ecological function within the Ruby River RVHA reach that restoration actions need to address include:
- Over-widened channel that limits floodplain connectivity and aquatic habitat diversity
- Perched floodplain surfaces that limit floodplain connectivity and support degraded riparian habitats
- Conversion of floodplain surfaces to introduced pasture grasses
- Simplified aquatic habitat

Geum Environmental Consulting
307 STATE ST
HAMILTON, MT 59840
406.363.2353
geumconsulting.com

DATUM: North American Datum 1983

PROJECTION: Montana State Plane

UNIT: US Foot

DATA SOURCES:
USDA NAIP Imagery, 2017
Madison County Cadastral, 2019

EXISTING CONDITION

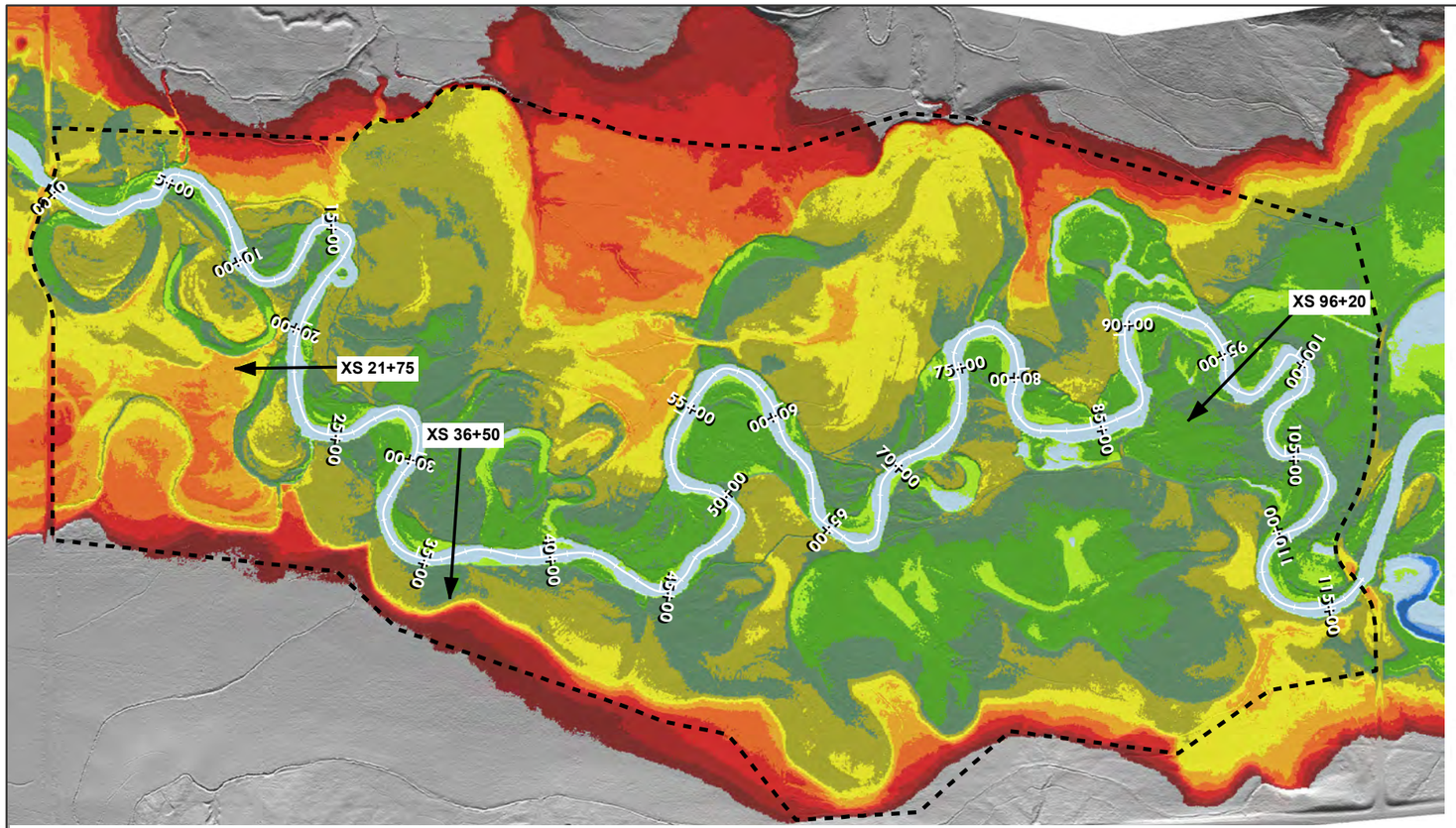
RUBY RIVER RVHA RESTORATION PROJECT
MADISON COUNTY, MONTANA

DRAWN BY: J. Wallace

DESIGNED BY: Geum, AGI, Gillilan

DATE: April 2021

SHEET
2.0



FLOODPLAIN CONNECTIVITY ANALYSIS AREA

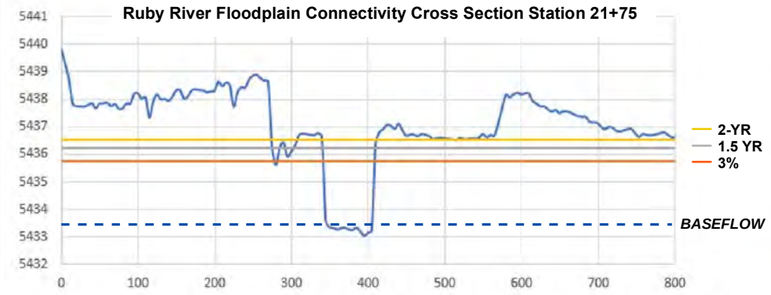
ELEVATION RELATIVE TO WATER SURFACE (FT)

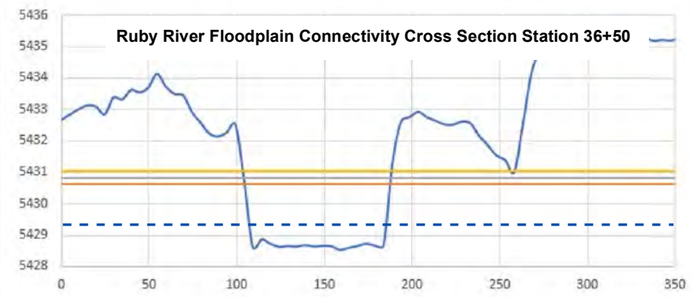
Connected Floodplain | Disconnected Floodplain

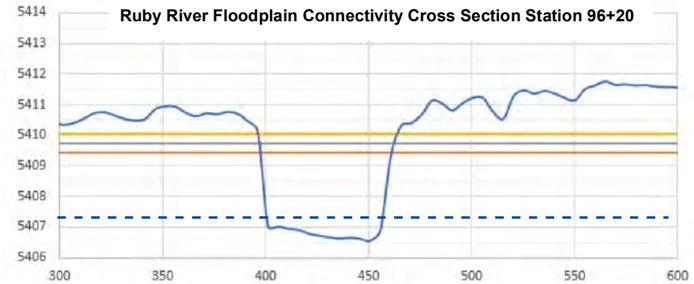
-4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 >11

N

Feet 0 500 1,000







FLOODPLAIN CONNECTIVITY SUMMARY

This map was created from LiDAR elevation data collected in September, 2018. This map shows the elevations of the floodplain relative to the water surface at the time the LiDAR data was collected, estimated to be approximately 130 cfs at the USGS *06019500 Ruby River above reservoir near Alder MT* gage located at the Cottonwood Creek Bridge. This flow corresponds with an approximate base flow or low flow condition in the river with an average water depth of 1 foot. This map shows the extent that the perched floodplain is disconnected from the current river channel and hydrology (See Table 2.1A). Floodplain surfaces within 2 feet of the baseflow water surface elevation are considered connected surfaces. Floodplain surfaces greater than 2 feet above the baseflow water surface elevation are considered disconnected surfaces that are not frequently accessed by out of bank flows.

To evaluate the extent to which the floodplain is perched and support design of treatments to reactivate the floodplain, a hydrologic analysis of the channel and floodplain were completed. This analysis was done using data from the USGS 06020600 Ruby River gage located at Cottonwood Creek bridge. Table 2.1B summarizes flows associated with flood intervals ranging from the 3% duration flow to 100 Year Peak Flood. Cross sections were taken from the LiDAR data to evaluate the capacity of the existing channel to contain the discharges typically seen in the Ruby River at this location. Example cross sections provided on this sheet that shows that more than a 2 Year Peak Flood is needed for flows to leave the current channel and access the floodplain. The channel forming or effective discharge of Rocky Mountain alluvial rivers is typically within the 3% duration to 1.5 year peak flood range.

Table 2.1A

Elevation Relative to Water Surface	Total Area (acres)	% of Area
0 - 1’	16.30	6.59%
1 - 2’	8.91	3.60%
2 - 3’	43.64	17.65%
3’ +	178.35	72.15%

Table 2.1B

Flood Interval	Discharge*
3% Duration	679 cfs
1.5 Year Peak Flood	830 cfs
2 Year Peak Flood	971 cfs
5 Year Peak Flood	1340 cfs
10 Year Peak Flood	1620 cfs
25 Year Peak Flood	1990 cfs
50 Year Peak Flood	2290 cfs
100 Year Peak Flood	2600 cfs

*Based on USGS 06020600 gage data with 73-year period of record

geum Environmental Consulting
307 STATE ST
HAMILTON, MT 59840
406.363.2353
geumconsulting.com

DATUM: North American Datum 1983

PROJECTION: Montana State Plane

UNIT: US Foot

DATA SOURCES:
AGI Relative Elevation Model, 2019

EXISTING CONDITION: FLOODPLAIN CONNECTIVITY

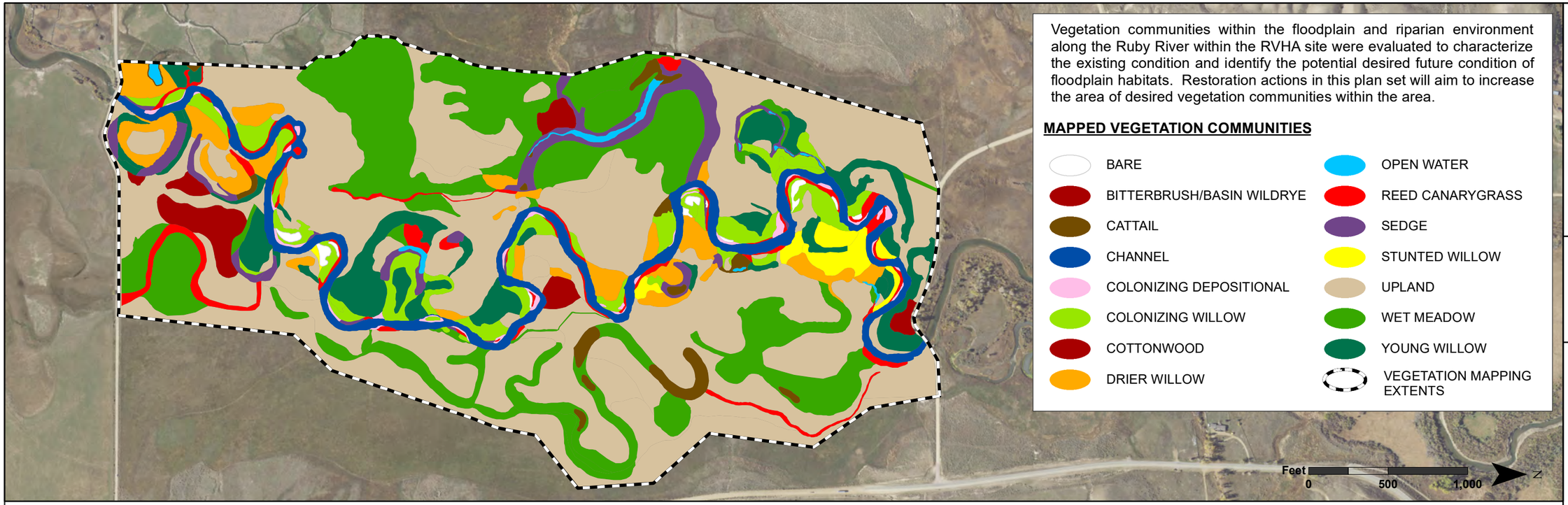
RUBY RIVER RVHA RESTORATION PROJECT
MADISON COUNTY, MONTANA

DRAWN BY: J. Wallace

DESIGNED BY: Geum, AGI, Gillilan

DATE: April 2021

SHEET
2.1



Vegetation Community	Acres	% of Area	Description	Desired Vegetation Community
Bare	0.86	0.35%	Higher, drier areas of alluvial deposition (small gravels, sand and silt) that have been colonized by little to no vegetation due to their high elevation above the water table. Plant species present include dry species such as common yarrow, rubber rabbitbrush or weedy species such as spotted knapweed.	No if high elevation
Bitterbrush/Basin wildrye	5.04	2.03%	Upland inclusions that occur along the margin of the floodplain on the east side of the river. These areas are dominated by native grasses, forbs and sub-shrubs and may represent the upland condition prior to grazing and agriculture. Dominant species include bitterbrush, snowberry, rabbitbrush, switchgrass, basin wildrye, Idaho fescue and white sagebrush.	Yes
Cattail	3.34	1.35%	Wetland areas that typically represent a transition between open water and sedge communities. Occur primarily in abandoned channel meanders (oxbow wetlands). These areas are very good at slowing overland flows, trapping and retaining fine sediment, and providing habitat for amphibians and waterfowl. Dominant species include common cattail, dagger-leaf rush, Nebraska sedge and hardstem bulrush.	Yes
Channel	13.49	5.44%		
Colonizing Depositional	1.24	0.50%	Areas along the channel that have recent alluvial deposition and are being colonized by early seral wetland and riparian vegetation such as spikerush, willow and cottonwood seedlings, rushes, or weedier species such as clover. These areas are key for establishment of new communities of desirable woody riparian vegetation.	Yes, represent primary succession for cottonwood and willow communities
Colonizing Willow	11.71	4.72%	Areas dominated by willow seedlings 2-3 years in age. Areas are typically lower elevation and willows are activate expanding. These areas often occur at the downstream end of meander cutoffs where significant fine sediment likely accumulated during the cut-off process. Areas are often co-dominated by reed canarygrass.	Yes, represent primary succession for cottonwood and willow communities
Cottonwood	0.48	0.20%	Only one stand present near Cottonwood Road that may be the result of flood deposition in 1964. Dominant species include: narrowleaf cottonwood, black cottonwood, common juniper, silverberry, snowberry, Wood's rose, water birch, bebb willow, Booth's willow and sandbar willow.	Yes
Decadent Willow	11.42	4.61%	Willow stands showing significant sign of decadence due to willow age or drying floodplain conditions. Willows in these areas are typically very old, with umbrella structure indicating a legacy of grazing. Very little willow expansion or new colonization is occurring in these areas. Willows are scattered in some of these areas. Dominant willow species include sandbar willow and bebb willow. The understory is typically dominated by drier species such as currant, Wood's use, smooth brome and snowberry. Weedy species such as Canada thistle are also often present.	Yes, vigor and diversity should increase with floodplain reconnection
Open Water	1.25	0.51%	Open water and backwater areas that occur within depressions in the floodplain that intercept groundwater. Typically unvegetated or vegetated with aquatic macrophytes. Occur primarily in the lowest elevation areas of abandoned channels (oxbow wetlands).	Yes, as a component of diverse floodplain wetlands
Reed Canarygrass	6.10	2.46%	Areas dominated by reed canarygrass, an introduced pasture grass that is highly invasive in wetlands and along river corridors. Reed canarygrass forms a monotype with few other species present. Young willows occur in some of these areas, but the understory is dominated by reed canarygrass. Sedges and rushes can occur in low depressions. Commonly occurs on fine sediment deposition along streambanks, ditches, intermixed in oxbow wetland with sedges, stunted willows, on md-channel islands.	No
Sedge	8.38	3.38%	Wetland areas dominated by sedges and rushes. Typically occur as a narrow strip immediately along the channel, around backwater depressions and in oxbow wetlands. These areas are very good at slowing overland flows, trapping and retaining fine sediment, and providing habitat for amphibians and waterfowl. Dominant species include beaked sedge, dagger-leaf rush and Nebraska sedge.	Yes
Stunted Willow	3.20	1.29%	These are young willow stands with high willow cover but intense browse creating a stunted appearance. Willows in these stands are often mixed with drier shrubs. Dominant species include Booth's willow and sandbar willow. Understory vegetation is dominated by smooth brome in drier areas and common timothy in wetter areas. These areas are concentrated on the east side of the river upstream of Cottonwood Road and typically occur in lower elevation areas of the floodplain. Willows may naturally expand in these areas if grazing pressure lessens.	Yes
Upland	113.34	45.73%	Dry areas dominated by introduced pasture grasses with very low cover of wetter species such as sedges, rushes and Rocky Mountain iris. The dominant species in upland areas is smooth brome. Uplands extend right up to the banks of the Ruby River in many areas and provide little stabilization for streambanks or cover to support aquatic habitat diversity.	Yes, with less cover of introduced grasses and further from the active channel
Wet Meadow	51.85	20.92%	Grass dominated areas wetter than uplands due to sub-irrigation from agriculture or groundwater seepage from adjacent slopes. Areas are typically dominated by introduced pasture grasses such as timothy, meadow foxtail and redtop, but also include varying amounts of wet native species such as arctic rush, Nebraska sedge, and common horsetail.	Yes, with less cover of introduced grasses
Young Willow	16.11	6.50%	Areas dominated by young willow communities. Young willow stands typically occur on low elevation inside meander bends and along oxbow wetlands. Several species of willows are present including sandbar willow, Booth's willow and bebb willow. The understory ranges from a mix of introduced pasture grasses such as field meadow foxtail to wetter, native species such as sedges.	Yes

geum Environmental Consulting
307 STATE ST
HAMILTON, MT 59840
406.363.2353
geumconsulting.com

DATUM: North American Datum 1983

PROJECTION: Montana State Plane

UNIT: US Foot

DATA SOURCES:
USDA NAIP Imagery, 2017

EXISTING CONDITION: FLOODPLAIN VEGETATION COMMUNITIES

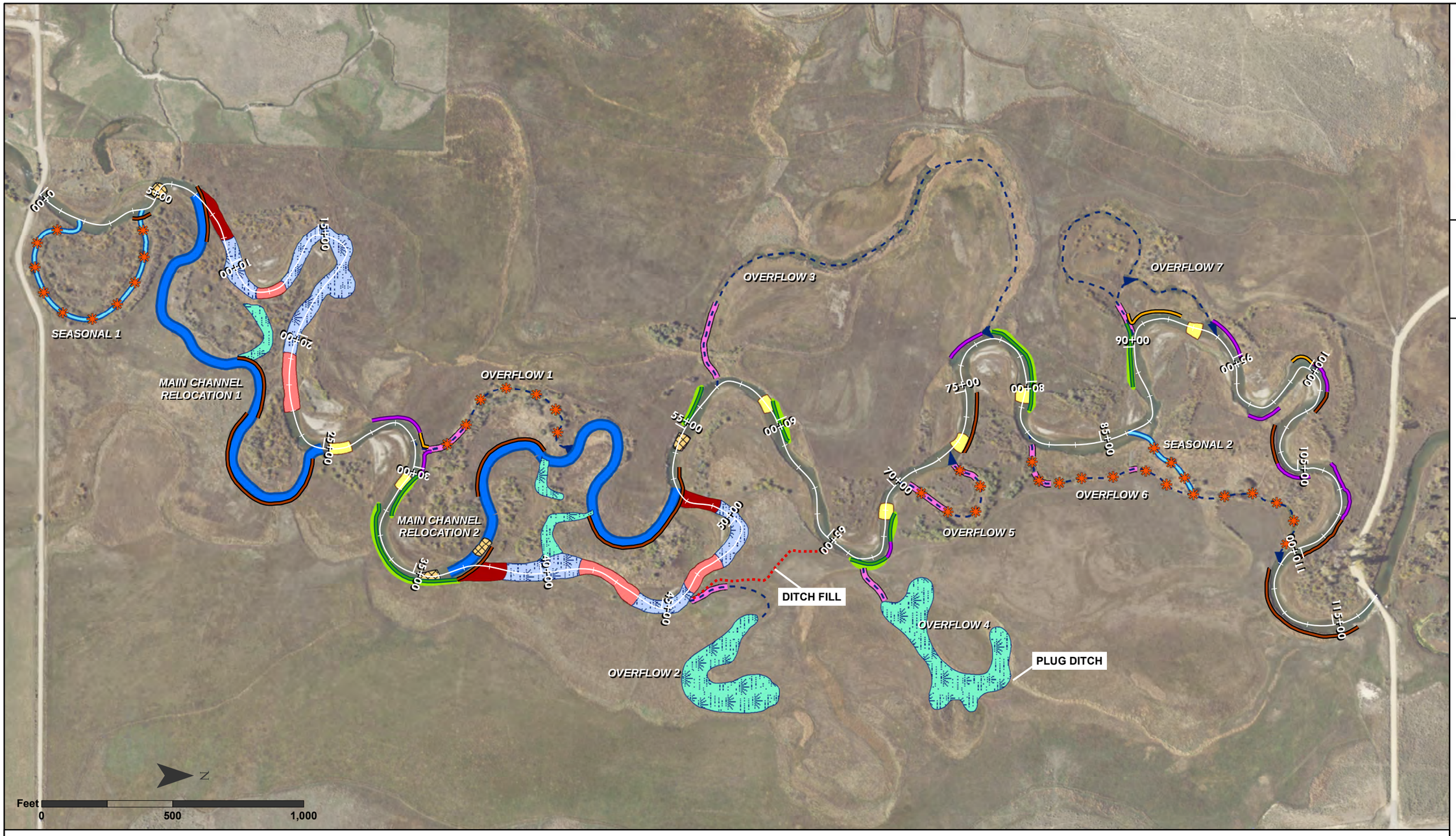
RUBY RIVER RVHA RESTORATION PROJECT
MADISON COUNTY, MONTANA

DRAWN BY: Jesse Wallace

DESIGNED BY: Amy Sacry

DATE: April 2021

SHEET
2.2



DESIGN RESTORATION TREATMENTS

- MAIN CHANNEL RELOCATION
- SEASONAL CHANNEL
- OVERFLOW CHANNEL
- OVERFLOW CHANNEL EXCAVATION
- BRUSH MATRIX W/ INSET FLOODPLAIN BANK TREATMENT
- BRUSH MATRIX BANK TREATMENT - TYPE 1
- BRUSH MATRIX BANK TREATMENT - TYPE 2
- BRUSH MATRIX BANK TREATMENT - TYPE 3
- DITCH FILL
- BED AGGRADATION STRUCTURE
- COARSEN RIFFLE
- MAIN CHANNEL PLUG
- MAIN CHANNEL PLUG - LOW PROFILE
- INSET FLOODPLAIN
- ABANDONED CHANNEL WETLAND SHAPING
- WETLAND ENHANCEMENT
- BEAVER DAM ANALOG

Geum Environmental Consulting
307 STATE ST
HAMILTON, MT 59840
406.363.2353
geumconsulting.com

DATUM: North American Datum 1983

PROJECTION: Montana State Plane

UNIT: US Foot

DATA SOURCES:
USDA NAIP Imagery, 2017

RESTORATION TREATMENT OVERVIEW

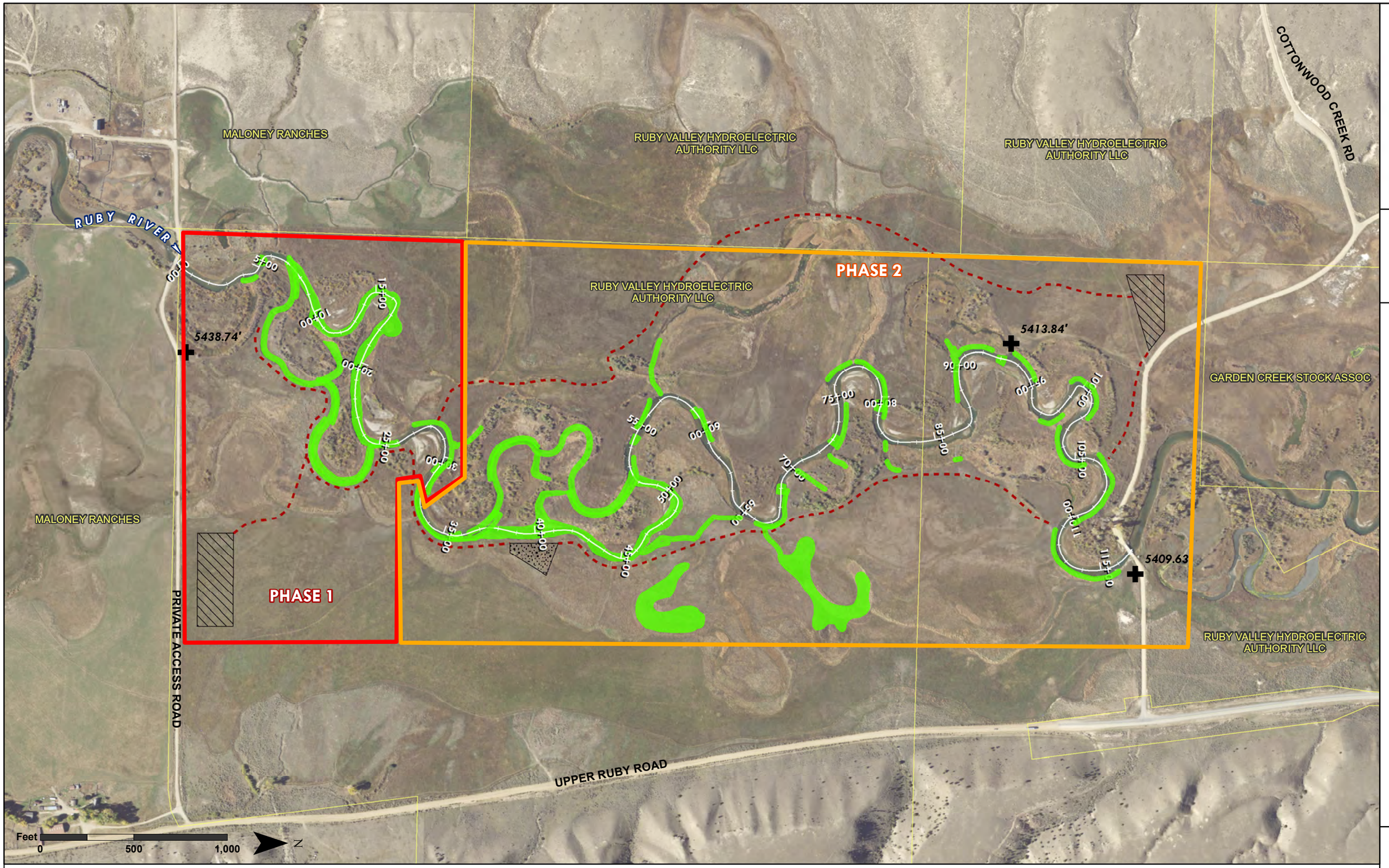
RUBY RIVER RVHA RESTORATION PROJECT
MADISON COUNTY, MONTANA

DRAWN BY: J. Wallace

DESIGNED BY: Geum, AGI, Gillilan

DATE: April 2021

SHEET
3.0



EQUIPMENT & MATERIALS STAGING AREA

PHASE 1 EXCESS MATERIAL STOCKPILE

APPROXIMATE PRIMARY WORK ACCESS ROUTES

SURVEY BENCHMARK

PROJECT WORK EXTENTS

PARCEL BOUNDARY

Geum Environmental Consulting
307 STATE ST
HAMILTON, MT 59840
406.363.2353
geumconsulting.com

DATUM: North American Datum 1983

PROJECTION: Montana State Plane

UNIT: US Foot

DATA SOURCES:
USDA NAIP Imagery, 2017
Madison County Cadastral, 2019

SITE PLAN

RUBY RIVER RVHA RESTORATION PROJECT
MADISON COUNTY, MONTANA

DRAWN BY: J. Wallace

DESIGNED BY: Geum, AGI, Gillilan

DATE: April 2021

SHEET
3.1

RESTORATION GOAL AND TREATMENTS

The goal for the Ruby River RVHA project is to optimize ecological functions within the river and the floodplain. To achieve this goal, the restoration actions included in this plan set include reactivating old channel meanders, locally raising the bed of the river to raise the groundwater table in the adjacent riparian and floodplain environments, constructing channels to activate floodplain surfaces, treating streambanks to restore woody shrub cover, and increasing floodplain diversity. Restoration treatment locations are shown on Sheet 3.0, and each type of restoration treatment is described below:

CHANNEL REACTIVATION

Channel reactivation aims to reconnect the Ruby River with the perched floodplain and improve instream fish habitat. Several types of channel reactivations are proposed, including: reactivations of the entire main channel (Main Channel Relocation), reactivations that just provide overflow into existing channels and depressions in the floodplain (Overflow Channel), and construction of new floodplain channels (Seasonal Channel). Channel reactivation will be done by locally checking up the elevation of the channel bed in most places. Reactivations that include the entire main channel will be done by plugging the main channel and constructing new channels through the floodplain in each Main Channel Relocation area. Details on the types of channel reactivations are provided on Sheet 3.2. All channel reactivations will incorporate aquatic habitat enhancement features such as: pools and riffles, streambank treatments aimed at increasing cover and woody riparian vegetation, preservation of existing high-quality habitat and/or vegetation, and incorporation of roughness elements as needed. Channel spanning woody debris structures that mimic beaver dams (Beaver Dam Analog) and help retain water and route high flows onto adjacent floodplains would also be constructed in some overflow channels and seasonal channels.

BED AGGRADATION STRUCTURE

To reactivate channels and increase floodplain connectivity, structures will be built on the channel bed to raise the water surface elevation allowing some of the channel flow to route into old channel meanders or floodplain features. Bed Aggradation Structures are built on existing riffles using layers of cobble and rock.

CHANNEL PLUG

In areas where most main channel flows will be routed into a new channel, a full channel plug will be constructed across the main channel. These plugs are constructed using layers of cobble, gravel, and riprap. The upstream face of channel plugs will consist of woody debris matrix streambank treatment that will form the bank of the new channel.

WOODY DEBRIS MATRIX STREAMBANK

This treatment is used to build new streambanks or restore existing, actively eroding streambanks. The intent of these structures is to create conditions directly along the channel that increase roughness to slow erosion, provide cover and shade, and allow desirable woody, riparian vegetation to establish. Woody debris matrix streambanks are constructed using layers of salvaged willow clumps or other woody debris, and alluvium. Dormant willow cuttings may be incorporated as needed. Three types of Woody Debris Matrix Streambank Treatments will be used: Type 1 is used in areas with little active toe erosion and preserves the existing streambank toe material; Type 2 is used where there are deep pools and adds roughness, such as juniper branches or small trees to the toe for aquatic habitat enhancement; and Type 3 is used along poorly vegetated banklines, and where the toe is actively eroding and adds large cobble toe protection.

INSET FLOODPLAIN

Inset floodplains are a treatment used to narrow over-widened sections of channel while improving bankline habitat. These structures consist of a low bench built in front of an existing bank line to reduce channel capacity in over-widened streams. They are built using gravel and cobble and a Woody Debris Matrix Streambank Treatment is constructed along the face of each inset floodplain to form the new bankline.

WETLAND CREATION and ENHANCEMENT

Wetlands and topographically diverse floodplain surfaces will be created as part of restoration actions. Wetlands will be created and enhanced in abandoned channel segments and in and along seasonal and overflow channel activation areas. Wetland creation and enhancement includes creating surfaces with varying depths and gradual slopes to create a wide range of habitats capable of supporting a wide range of plant communities. Wetland enhancement may also include varying substrates, placing woody debris, and transplanting salvaged wetland sod and riparian shrubs. In some areas, wetland enhancement will be done by increasing how much water is routed to an area. Increasing the hydrology of an area will increase wetland area and allow introduced grass species to convert to native wetland species.

SUMMARY OF RESTORATION TREATMENT QUANTITIES

Restoration Treatment	Number of Structures	Unit	Quantity
Main channel relocation	*NA*	Linear ft	3,830
Seasonal channel construction	*NA*	Linear ft	1,515
Overflow channel (constructed)	*NA*	Linear ft	1,360
Overflow channel (activated - no construction)	*NA*	Linear ft	7,580
Bed aggradation structure	7	Each	7
Coarsen riffles	4	Each	4
Main channel plug	3	Square ft	26,735
Main channel plug - Low profile	4	Square ft	39,305
Abandoned channel wetland shaping	*NA*	Square ft	111,715
Wetland enhancement	*NA*	Square ft	179,735
Inset Floodplain	*NA*	Square ft	18,815
Brush Matrix with Inset Floodplain	8	Linear ft	1,917
Brush Matrix Type 1	3	Linear ft	415
Brush Matrix Type 2	9	Linear ft	1,388
Brush Matrix Type 3	12	Linear ft	3,787
Beaver Dam Analog	38	Each	38

FLOODPLAIN TREATMENT

Floodplain treatment includes increasing topographic diversity and roughness of floodplain surfaces to reduce erosion and increase retention of fluvially transported sediment and plant propagules. Floodplain treatment includes constructing small depressions and hummocks on the floodplain surface and scattering and burying woody debris across the surface. Floodplain treatment locations are not shown on Sheet 3.0. Floodplain treatments will be used on inset floodplains and in wetland enhancement areas.

VEGETATION PRESERVATION, SALVAGE & TRANSPLANT

Preservation of desirable floodplain vegetation will be maximized to the extent possible. Desirable vegetation located within areas to be disturbed during streambank construction or channel activations will be salvaged and transplanted along new channel activations, within streambanks, on floodplain surfaces, or within created wetlands.

geum Environmental Consulting
307 STATE ST
HAMILTON, MT 59840
406.363.2353
geumconsulting.com

RESTORATION TREATMENT SUMMARY

RUBY RIVER RVHA RESTORATION PROJECT
MADISON COUNTY, MONTANA

DRAWN BY: J. Wallace
DESIGNED BY: Geum, AGI, Gillilan
DATE: April 2021

SHEET
3.2

CHANNEL ACTIVATION SUMMARY

Identifying an appropriate channel forming/effective discharge is key to achieving the restoration goal. This flow is used to determine channel design dimensions and how much flow can be routed down seasonal activation and overflow channels. USGS stream gage data for a 73-year period, along with existing channel dimensions, were evaluated to select the discharge to target for channel activations and to develop a template for main channel relocations. The table below represents the flood return flow intervals and corresponding discharges commonly used in stream restoration channel design. 700 cfs was selected as the effective discharge for the Ruby River Restoration Project design. It is both the flow that is met or exceeded 3% of the annual record which has been correlated to effective discharge in snowmelt driven gravel bed rivers. It is expected to occur at an approximate 1.2-year return interval. This return frequency is also desirable as it suggests all channels will be wetter on an almost annual basis.

Flood Return Flow Interval	Estimated Discharge (cfs)
Q2	969 - 989 cfs
Q1.5	800 - 835 cfs
Q1.2 (3% duration or 11 days)	690 cfs
Baseflow	130 cfs

CHANNEL ACTIVATION DESCRIPTIONS

MAIN CHANNEL RELOCATION

These activations will carry the bulk of flows up to about 500 cfs, at which point flows will split into both the new and old channels. These channels will require some excavation and shaping to create habitat and effectively route the main flow through them. Flows above ~500 cfs will route down both the new and the abandoned current main channel. The existing main channel will be plugged with a full channel plug with a top height equivalent to the stage height of the effective flow discharge. The abandoned main channel will be shaped into a series of wetland ponds and diverse floodplain features. Main channel reactivations will incorporate aquatic habitat enhancement features such as: shaping of pools and riffles, streambank treatments aimed at increasing cover and woody riparian vegetation, preservation of existing high-quality habitat and/or vegetation, and incorporation of roughness elements where needed for stability. The table and cross-sections provide design dimensions for the main channel relocations.

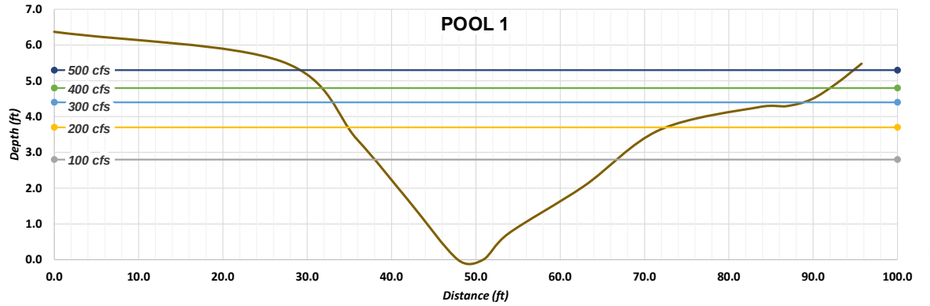
	Pool 1	Pool 2	Pool 3	Riffle 1	Riffle 2
Bottom width	4	4	10	36	37
Top width at ~500 cfs	70	64	64	56	56
Max Depth at ~500 cfs	5.3	5.8	4.6	2.5	3
Cutbank Slope	3	2.8	2.8	2.00	7.90
Point Bar Slope	10.9	10.5	15.5	5	2.90
Width to /Depth Ratio	13.2	11.0	13.9	22.4	18.70

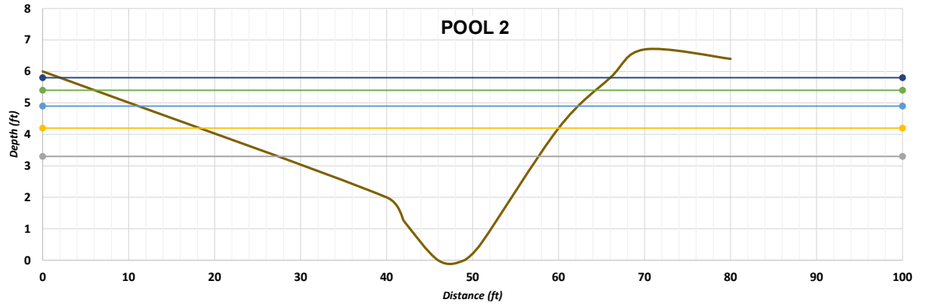
SEASONAL FLOW CHANNEL

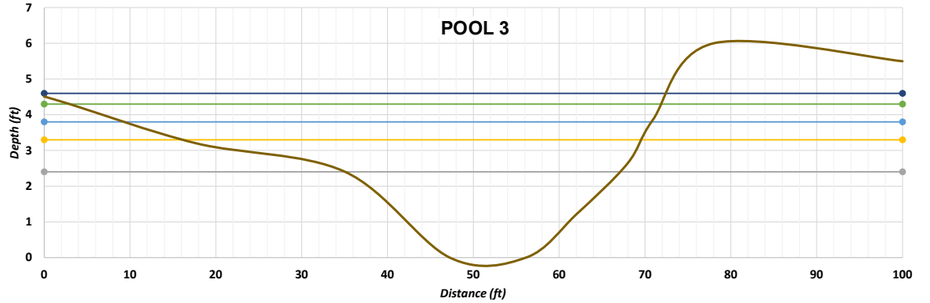
This activation requires excavation of a channel to route flows through the feature. The amount of flow and number of days activated varies by location and depends on the existing elevation of the feature to be activated relative to the bed elevation of the main channel. One seasonal flow activation constructs a channel through an abandoned meander (Seasonal Flow #1). The dimensions of each seasonal flow channel depends on activation stage and activation discharge (see Sheet 4.0). Seasonal flow channel activations will incorporate aquatic habitat enhancement features such as: shaping of pools and riffles, streambank treatments aimed at increasing cover and woody riparian vegetation, preservation of existing high-quality habitat and/or vegetation, channel spanning woody debris structures to route high flows into adjacent floodplains, and incorporation of roughness elements where needed for stability.

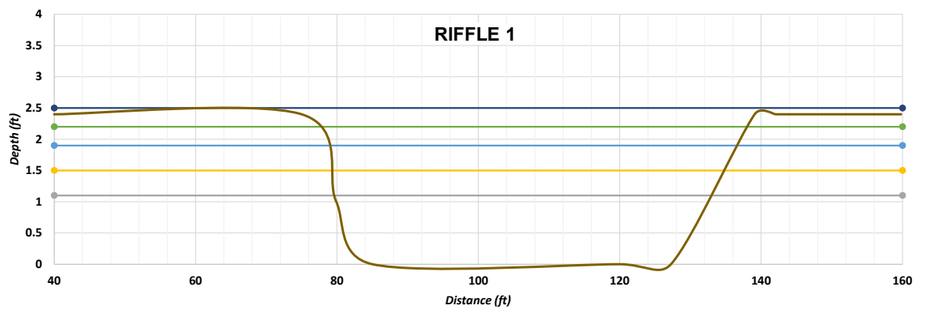
OVERFLOW CHANNEL

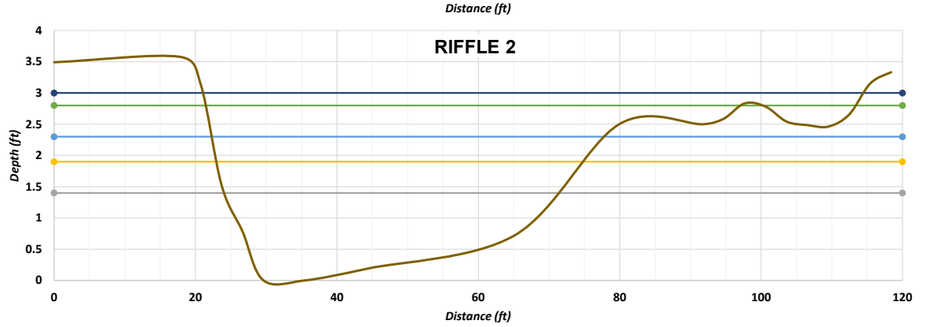
This type of channel activation will be done by lowering the inlet, outlet or high elevation sections within an existing perched floodplain feature to activate the feature. The amount of flow and number of days activated varies by location and depends on the existing elevation of the feature to be activated relative to the bed elevation of the main channel. These areas will be activated through construction of pilot channels or swales. Once flows enter the activated feature beyond the pilot channel they will disperse throughout the feature following existing flow paths. The dimensions of each pilot channel varies depending on the activation stage and activation discharge (see Sheet 4.0). Overflow channel activations will incorporate aquatic habitat enhancement features such as: shaping of pools and riffles, streambank treatments aimed at increasing cover and woody riparian vegetation, preservation of existing high-quality habitat and/or vegetation, channel spanning woody debris structures to route high flows into adjacent floodplains, and incorporation of roughness elements where needed for stability.











geum Environmental Consulting
307 STATE ST
HAMILTON, MT 59840
406.363.2353
geumconsulting.com

DATUM:

PROJECTION:

UNIT: INTL FT

DATA SOURCES:

CHANNEL ACTIVATION TEMPLATES

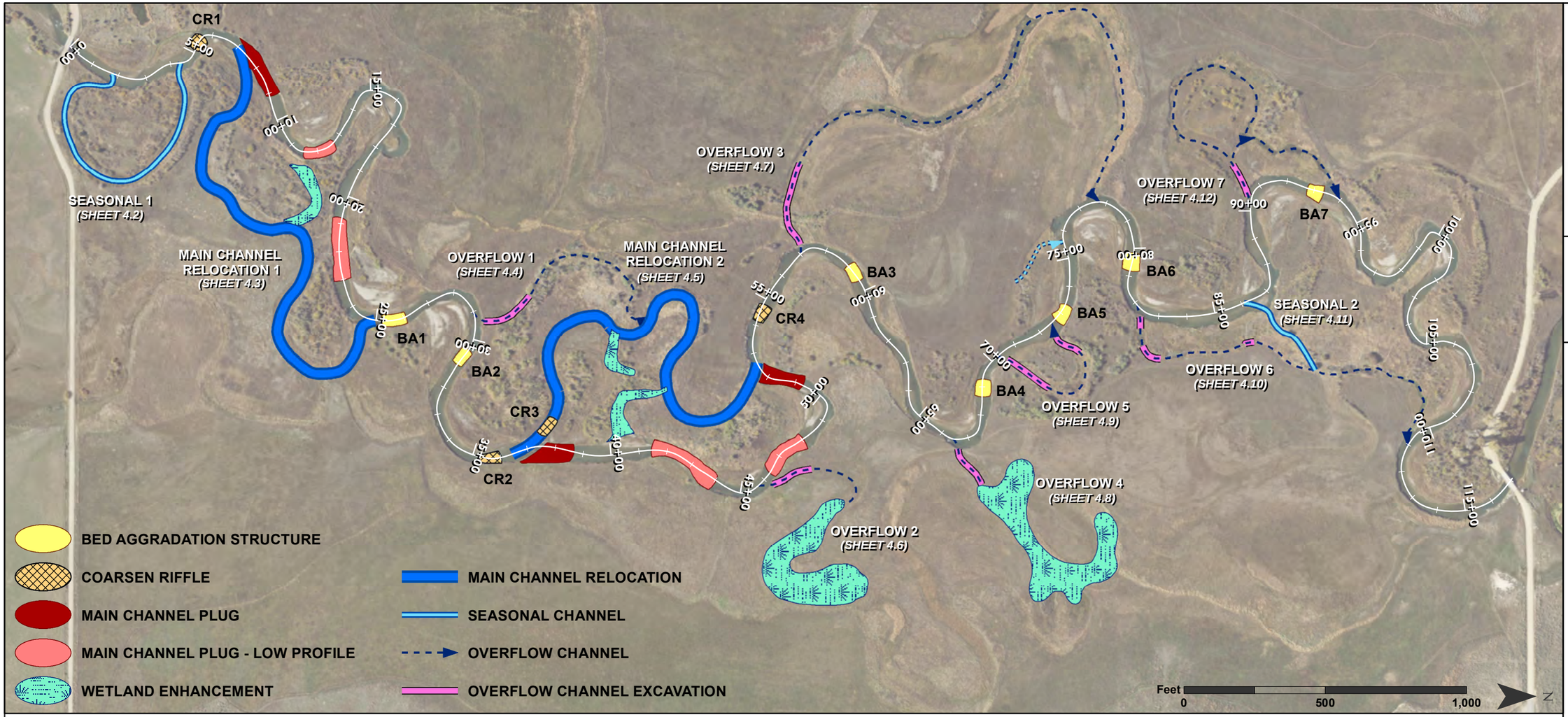
RUBY RIVER RVHA RESTORATION PROJECT
MADISON COUNTY, MONTANA

DRAWN BY: J. Wallace

DESIGNED BY: Geum, AGI, Gillilan

DATE: April 2021

SHEET
3.3



Channel Activation	Main Channel Start Station	Main Channel End Station	Total Constructed Channel Length (ft)	Total Activated Channel Length (ft)	Activation Stage (ft)	Activation Q (cfs)	Days / Year Activated	Channel Template Dimensions
Seasonal 1	1+78	4+37	1075	*N/A*	2.3	480	26	Channel 10’ wide, 1.5’ deep
Main Channel 1	6+99	24+59	1880	*N/A*	0	0	365	Main Channel *(See Sheet 3.3)*
Overflow 1	29+02	*N/A*	200	645	1.9	400	29	Pilot Channel 10’ wide, 1.0’ deep
Main Channel 2	37+00	52+64	1950	*N/A*	0	0	365	Main Channel *(See Sheet 3.3)*
Overflow 2	45+73	*N/A*	625	390	*N/A*	*N/A*	*N/A*	Pilot Channel 10’ wide, 1.5' deep
Overflow 3	56+98	77+75	340	1985	2.5	670	11	Pilot Channel 10’ wide, 1.5' deep
Overflow 4	66+46	*N/A*	160	645	2	340	37	Pilot Channel 10’ wide, 1.5' deep
Overflow 5	70+22	72+54	295	240	0.8	80	354	Pilot Channel 10’ wide, 0.5’ deep
Overflow 6	82+10	111+08	285	1050	1.8	390	35	Pilot Channel, 10’ wide 1’ deep
Seasonal 2	86+08	*N/A*	170	105	2	470	26	Channel 10’ wide, 1.5’ deep
Overflow 7	90+23	93+95	105	1290	2	330	37	Pilot Channel 10’ wide, 1’ deep

Geum Environmental Consulting
307 STATE ST
HAMILTON, MT 59840
406.363.2353
geumconsulting.com

DATUM: North American Datum 1983

PROJECTION: Montana State Plane

UNIT: US Foot

DATA SOURCES:
USDA NAIP Imagery, 2017

CHANNEL ACTIVATION PLANVIEW

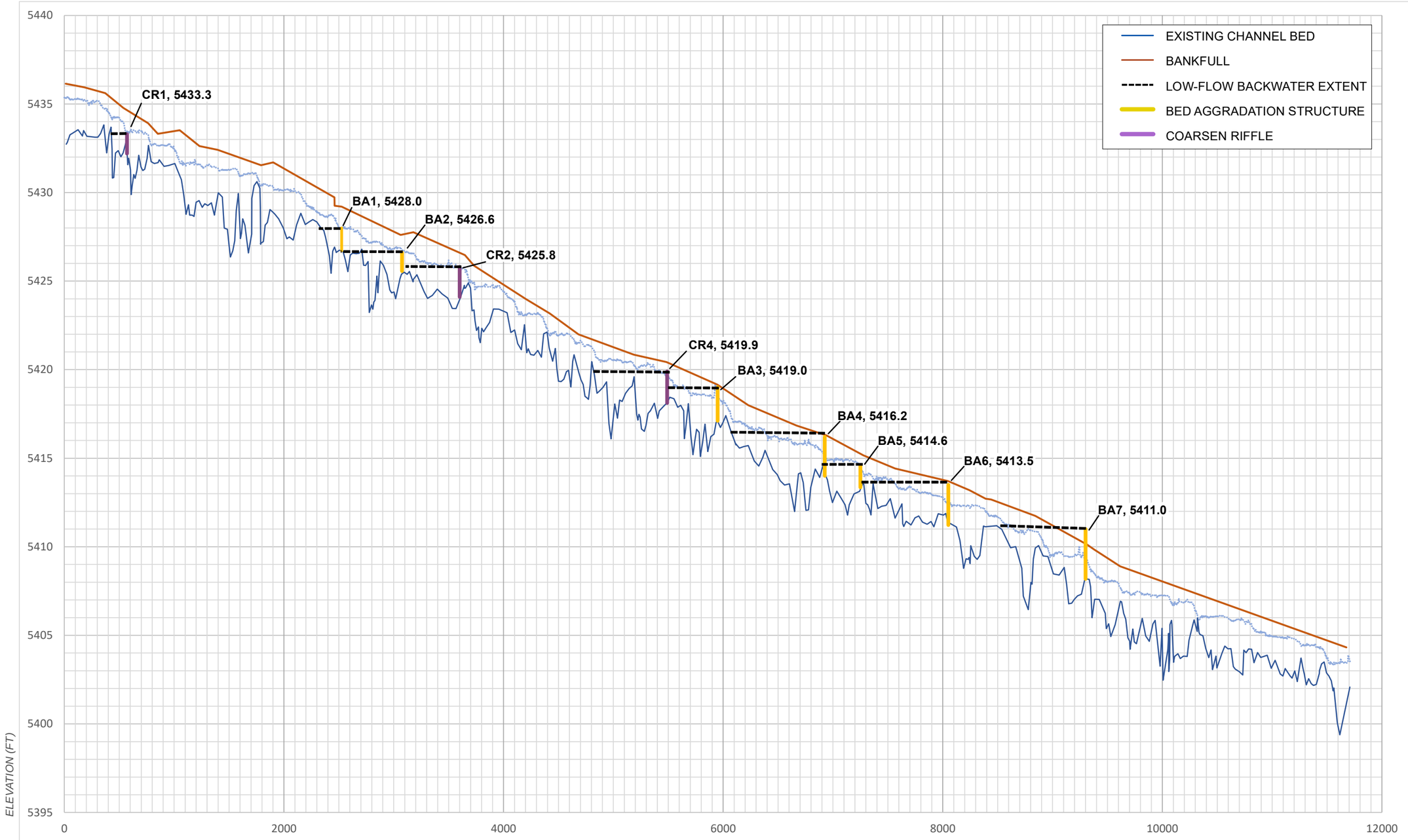
RUBY RIVER RVHA RESTORATION PROJECT
MADISON COUNTY, MONTANA

DRAWN BY: J. Wallace

DESIGNED BY: Geum, AGI, Gillilan

DATE: April 2021

SHEET
4.0



Structure	Station	Target Elevation	Max Structure Height (ft)	Mean Structure Height (ft)
Coarsen Riffle 1 (CR1)	5+70	5433.3	1.1	0.6
Bed Aggradation 1 (BA1)	25+25	5428	1.3	0.5
Bed Aggradation 2 (BA2)	30+75	5426.6	1.2	0.4
Bed Aggradation 3 (BA3)	59+50	5419	1.9	1.2
Coarsen Riffle 2 (CR2)	36+00	5425.8	2.3	2.0
Coarsen Riffle 3 (CR3)*	38+50*	5425.5	1.5	1

Structure	Station	Target Elevation	Max Structure Height (ft)	Mean Structure Height (ft)
Coarsen Riffle 4 (CR4)	54+90	5419.9	1.8	0.6
Bed Aggradation 4 (BA4)	69+25	5416.2	2.2	1.4
Bed Aggradation 5 (BA5)	72+50	5414.6	1.2	0.7
Bed Aggradation 6 (BA6)	80+50	5413.5	2.3	1.6
Bed Aggradation 7 (BA7)	93+00	5411	2.8	2.1

Structure CR3 is located on the MC2 realignment channel and is not shown in the chart above

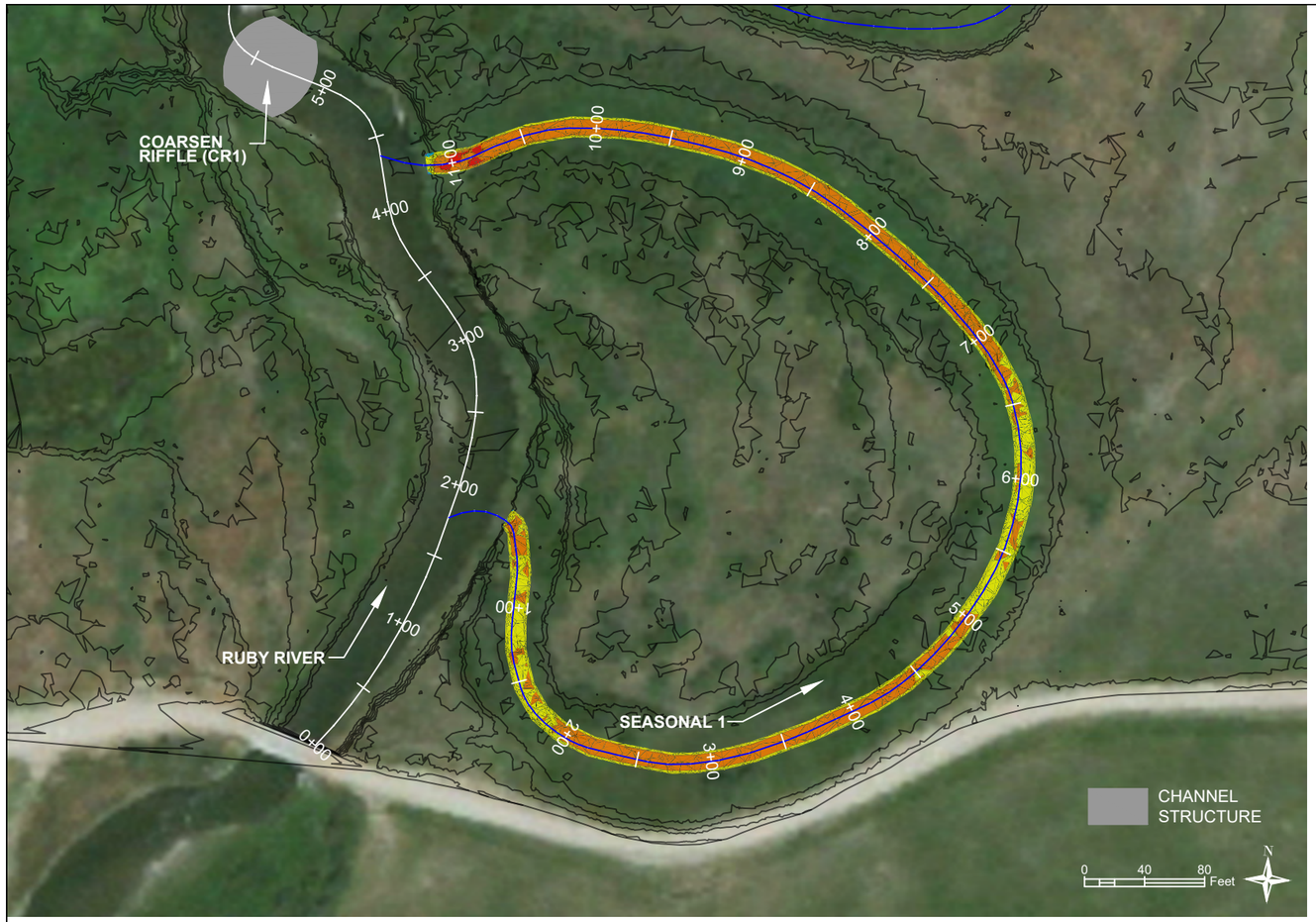
geum Environmental Consulting
307 STATE ST
HAMILTON, MT 59840
406.363.2353
geumconsulting.com

PROFILE and STRUCTURE HEIGHTS

RUBY RIVER RVHA RESTORATION PROJECT
MADISON COUNTY, MONTANA

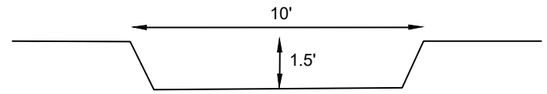
DRAWN BY: J. Wallace
DESIGNED BY: Geum, AGI, Gillilan
DATE: April 2021

SHEET
4.1

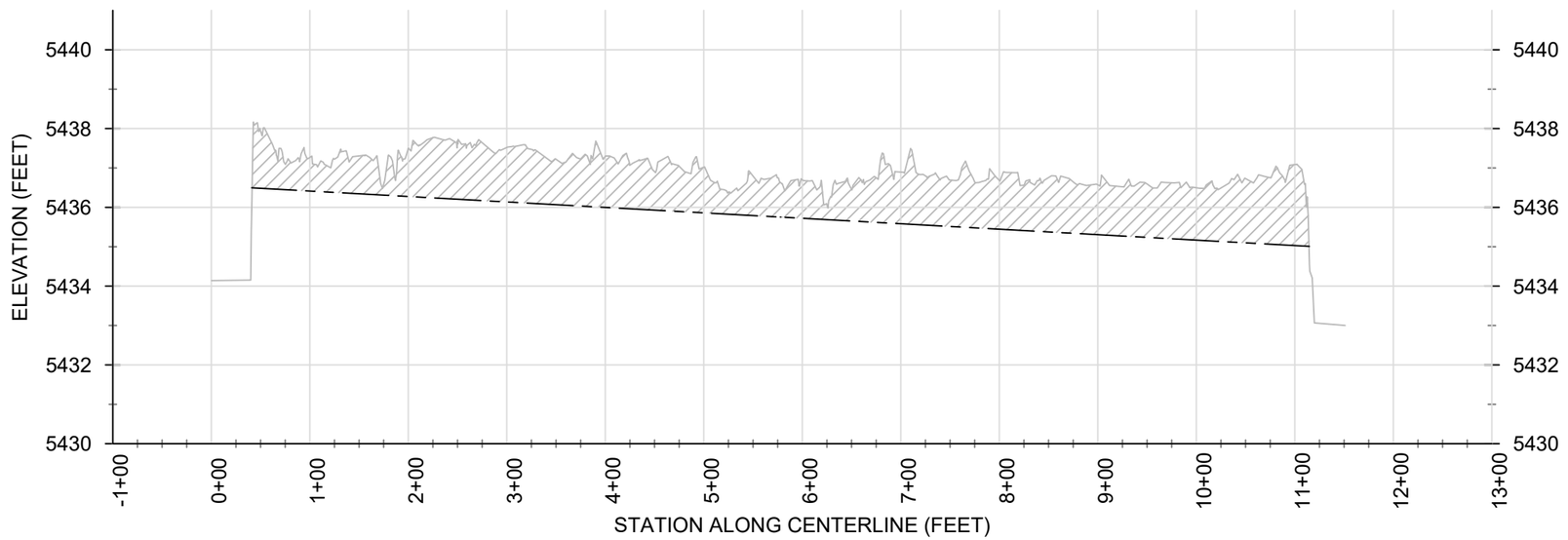


ACTIVATION CHANNEL DETAILS	
MAIN CHANNEL START STATION	1+78
MAIN CHANNEL END STATION	4+37
ACTIVATED CHANNEL LENGTH (FT)	N/A
CONSTRUCTED CHANNEL LENGTH (FT)	1075
TARGET INLET ELEVATION (FT)	5436.5
TARGET OUTLET ELEVATION (FT)	5435.0
ACTIVATION STAGE ABOVE BED (FT)	2.3
ACTIVATION Q (CFS)	480
DAYS PER YEAR ACTIVATED	26
SLOPE	0.14%

SEASONAL 1
TYPICAL CROSS SECTION



SEASONAL 1 - PROFILE VIEW



CUT/FILL		
COLOR	MIN. ELEVATION	MAX. ELEVATION
	-5.00	-4.00
	-4.00	-3.00
	-3.00	-2.00
	-2.00	-1.00
	-1.00	0.00
	0.00	1.00

ESTIMATED EARTHWORK VOLUMES FOR CONSTRUCTED CHANNEL	
CUT (CY)	575
FILL (CY)	0

LEGEND

- EXISTING GROUND
- DESIGN THALWEG
- CHANNEL STRUCTURE
- EXCAVATION

Geum Environmental Consulting
307 STATE ST.
HAMILTON, MT 59840
406.363.2353
geumconsulting.com

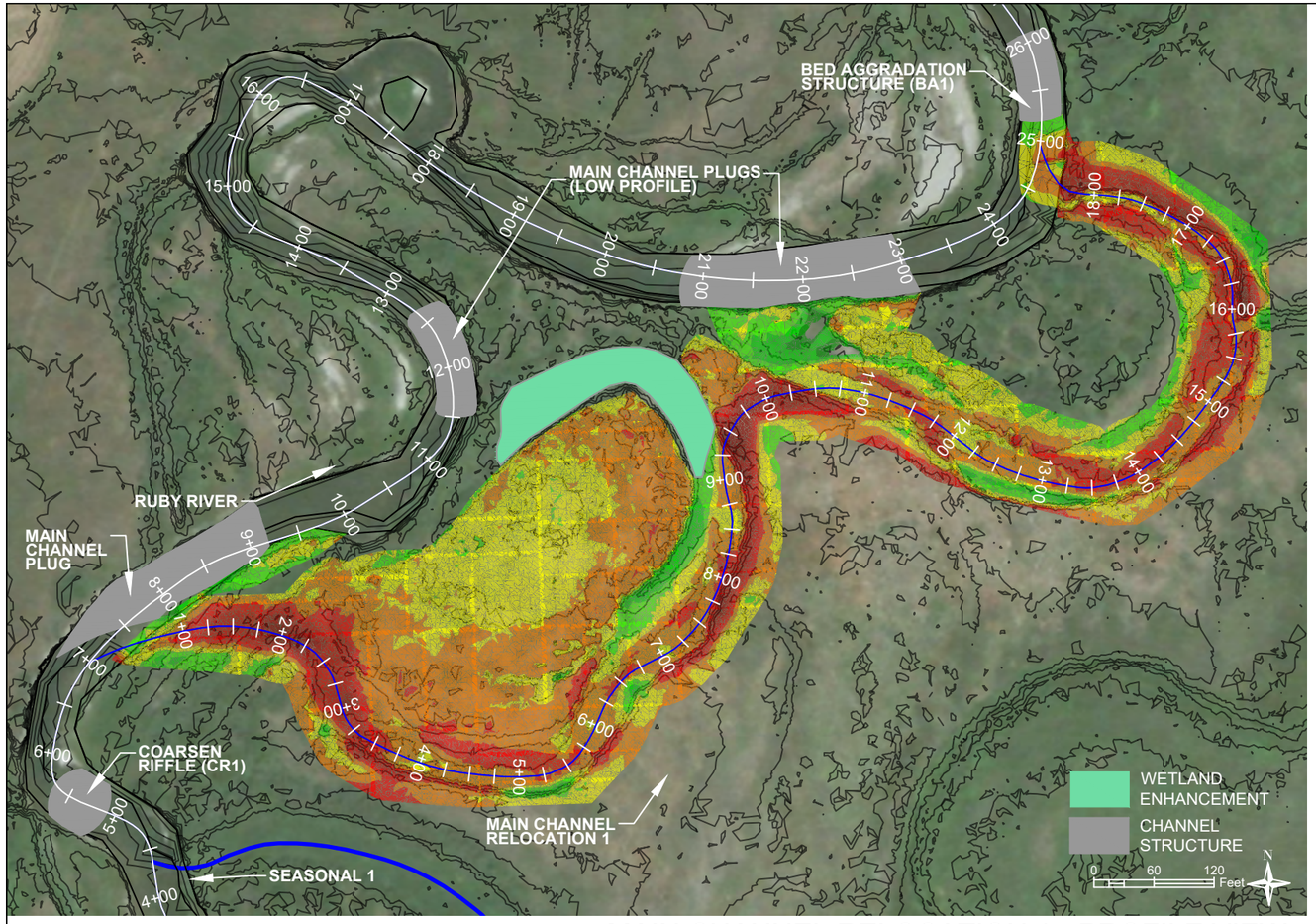
DATUM: North American Datum 1983
PROJECTION: Montana State Plane
UNITS: US Foot
DATA SOURCES: Digital Globe Imagery

ACTIVATION CHANNEL DETAILS
SEASONAL 1 DETAILS

RUBY RIVER RVHA RESTORATION PROJECT
MADISON COUNTY, MONTANA

DRAWN BY: A.Gulley
DESIGNED BY: Geum, AGI, Gillilan
DATE: April 2021

SHEET
4.2



ACTIVATION CHANNEL DETAILS	
MAIN CHANNEL START STATION	6+99
MAIN CHANNEL END STATION	24+59
ACTIVATED CHANNEL LENGTH (FT)	N/A
CONSTRUCTED CHANNEL LENGTH* (FT)	1810
TARGET INLET ELEVATION (FT)	5433.0
TARGET OUTLET ELEVATION (FT)	5428.5
ACTIVATION STAGE ABOVE BED (FT)	0.0
ACTIVATION Q (CFS)	0
DAYS PER YEAR ACTIVATED	365
SLOPE	(ON PROFILE)
MAIN CHANNEL PLUG ELEVATION	5435.9
COARSEN RIFFLE STRUCTURE CR1 ELEVATION	5433.3
BED AGGRADATION STRUCTURE BA1 ELEVATION	5428.0

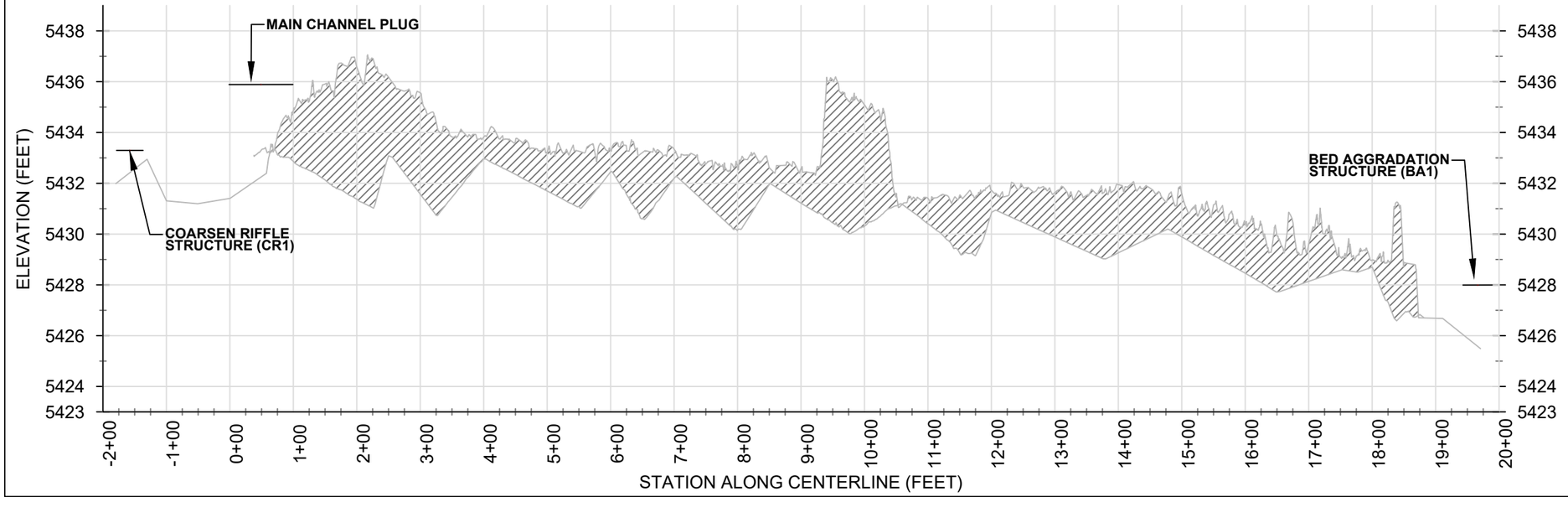
*TYPICAL CROSS SECTION DISPLAYED ON SHEET 3.2

LEGEND

- EXISTING GROUND
- DESIGN THALWEG
- CHANNEL STRUCTURE
- EXCAVATION

ESTIMATED EARTHWORK VOLUMES FOR CONSTRUCTED CHANNEL AND FLOODPLAIN	
CUT (CY)	12215
FILL (CY)	850

MAIN CHANNEL RELOCATION 1 - PROFILE VIEW



CUT/FILL		
COLOR	MIN. ELEVATION	MAX. ELEVATION
	-7.00	-6.00
	-6.00	-5.00
	-5.00	-4.00
	-4.00	-3.00
	-3.00	-2.00
	-2.00	-1.00
	-1.00	0.00
	0.00	1.00
	1.00	2.00
	2.00	3.00

Geum Environmental Consulting
307 STATE ST.
HAMILTON, MT 59840
406.363.2353
geumconsulting.com

DATUM: North American Datum 1983

PROJECTION: Montana State Plane

UNITS: US Foot

DATA SOURCES: Digital Globe Imagery

ACTIVATION CHANNEL MAIN CHANNEL RELOCATION 1 DETAILS

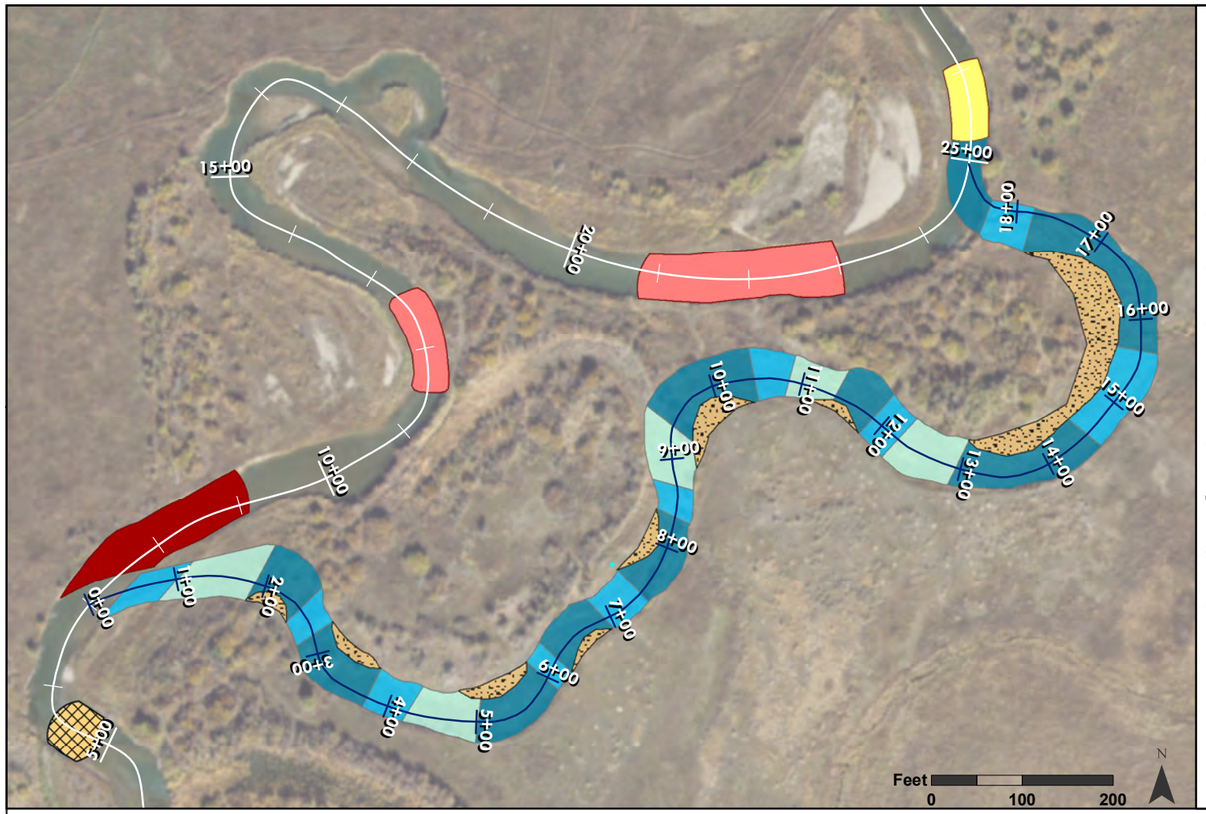
RUBY RIVER RVHA RESTORATION PROJECT
MADISON COUNTY, MONTANA

DRAWN BY: A.Gulley

DESIGNED BY: Geum, AGI, Gillilan

DATE: April 2021

SHEET
4.3



RELOCATION CHANNEL HABITAT UNITS

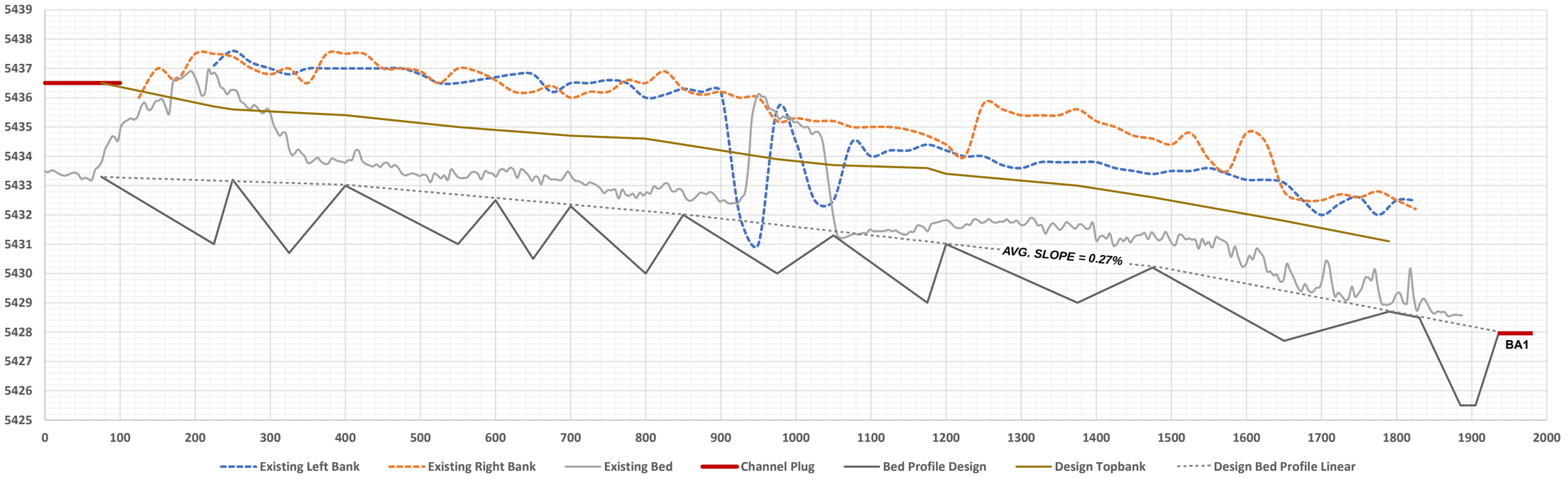
- POINT BAR
- POOL
- RIFFLE
- TRANSITION/RUN

ABANDONED CHANNEL TREATMENTS

- BED AGGRADATION STRUCTURE
- COARSEN RIFFLE
- MAIN CHANNEL PLUG
- MAIN CHANNEL PLUG - LOW PROFILE

RELOCATION 1 GRADING SCHEDULE

Station	Design Thalweg (ft)	Design TOB (ft)	Channel Feature
75	5433.3	5436.5	Pool Tie-in at entrance
225	5431	5435.7	Max Pool Depth
250	5433.2	5435.6	Riffle Crest
325	5430.7	5435.5	Max Pool Depth
400	5433	5435.4	Riffle Crest
550	5431	5435	Max Pool Depth
600	5432.5	5434.9	Riffle Crest
650	5430.5	5434.8	Max Pool Depth
700	5432.3	5434.7	Riffle Crest
800	5430	5434.6	Max Pool Depth
850	5432	5434.4	Riffle Crest
975	5430	5433.9	Max Pool Depth
1050	5431.3	5433.7	Riffle Crest
1175	5429	5433.6	Max Pool Depth
1200	5431	5433.4	Riffle Crest
1375	5429	5433	Max Pool Depth
1475	5430.2	5432.6	Riffle Crest
1650	5427.7	5431.8	Max Pool Depth
1790	5428.7	5431.1	Riffle Crest
1830	5428.5	*Existing main channel TOB*	Riffle Tie-in at outlet
1885	5425.5	*Existing main channel TOB*	Main Channel Max Pool Depth
MC 2480	5425.5	*Existing main channel TOB*	Main Channel Max Pool Depth
MC 2525	5427.9	*Existing main channel TOB*	Crest of Bed Aggradation Structure



geum Environmental Consulting
307 STATE ST
HAMILTON, MT 59840
406.363.2353
geumconsulting.com

DATUM: North American Datum 1983

PROJECTION: Montana State Plane

UNIT: US Foot

DATA SOURCES:
USDA NAIP Imagery, 2017

MAIN CHANNEL RELOCATION 1 GRADING nad HABITAT UNITS

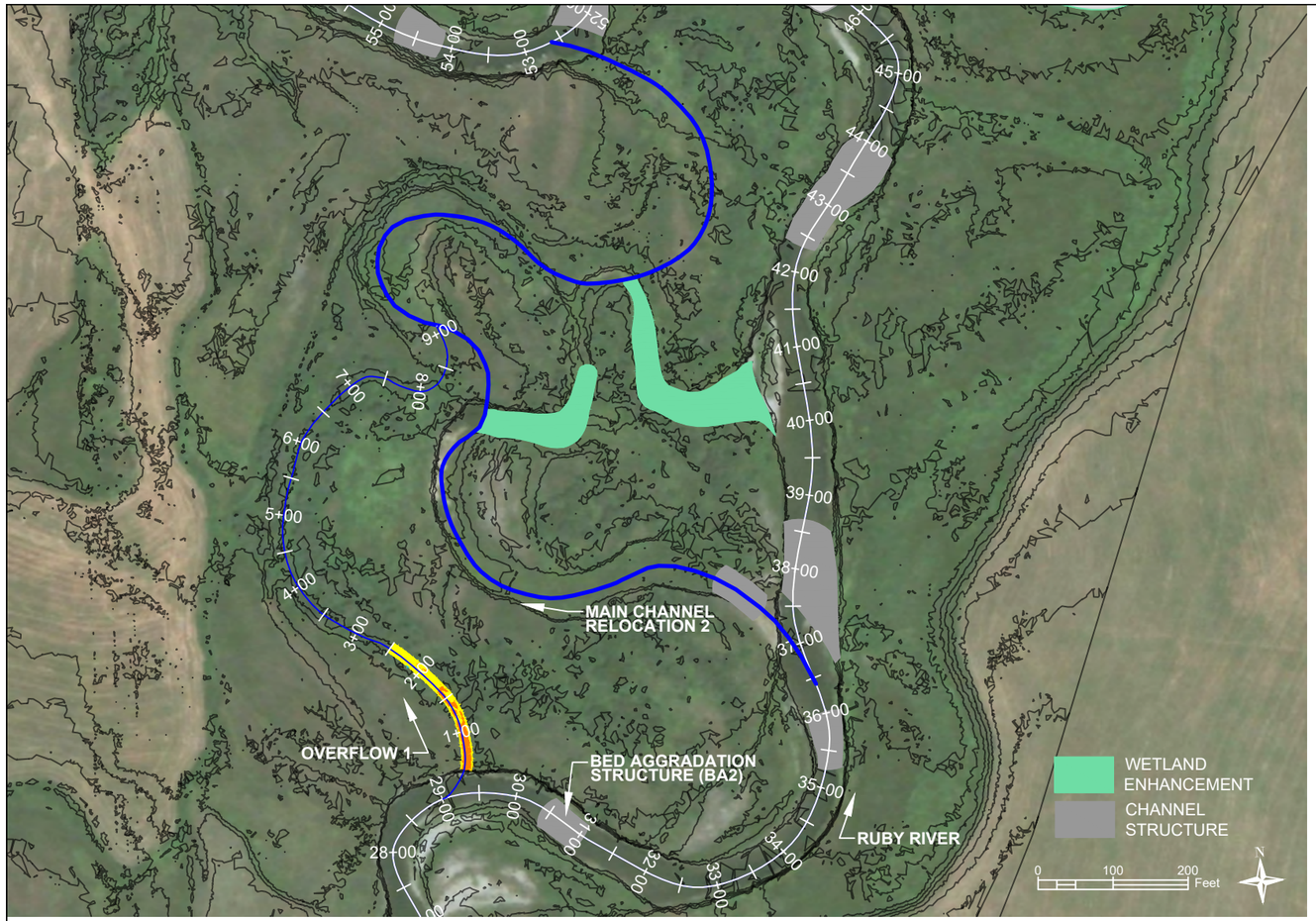
RUBY RIVER RVHA RESTORATION PROJECT
MADISON COUNTY, MONTANA

DRAWN BY: J. Wallace

DESIGNED BY: Geum, AGI, Gillilan

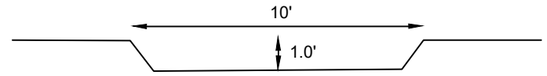
DATE: April 2021

SHEET
4.31

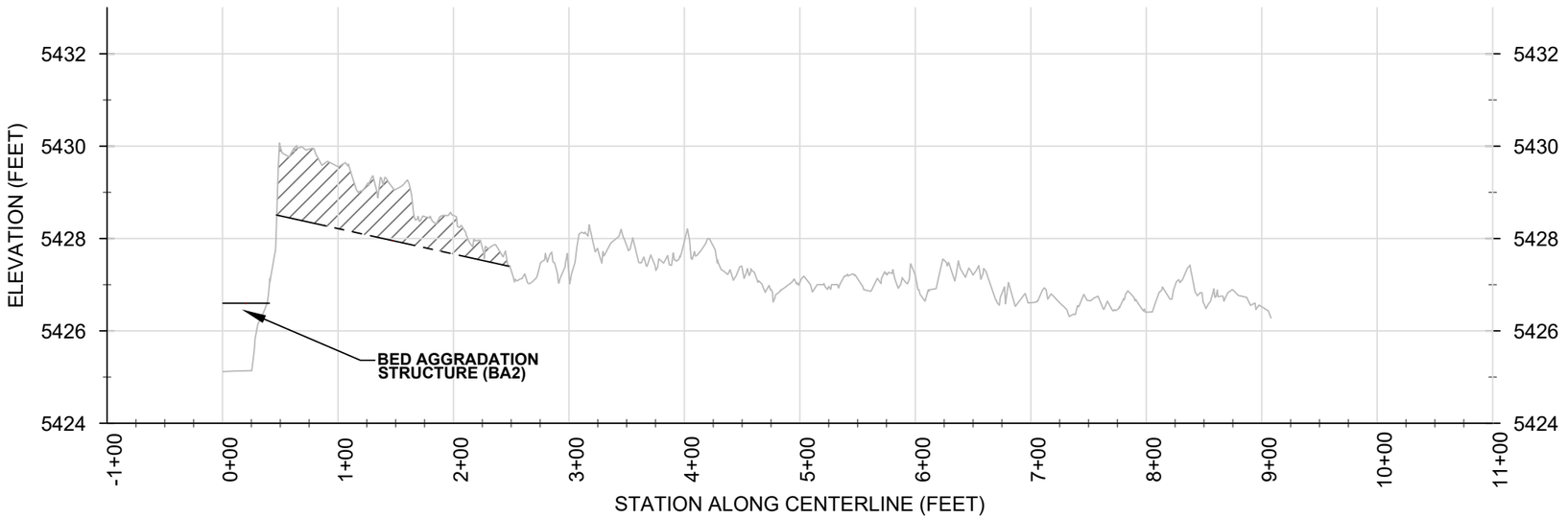


ACTIVATION CHANNEL DETAILS	
MAIN CHANNEL START STATION	29+02
MAIN CHANNEL END STATION	N/A
ACTIVATED CHANNEL LENGTH (FT)	645
CONSTRUCTED CHANNEL LENGTH (FT)	200
TARGET INLET ELEVATION (FT)	5428.5
TARGET OUTLET ELEVATION (FT)	N/A
ACTIVATION STAGE ABOVE BED (FT)	1.9
ACTIVATION Q (CFS)	400
DAYS PER YEAR ACTIVATED	29
SLOPE	0.30%
BED AGGRADATION STRUCTURE BA2 ELEVATION	5426.6

OVERFLOW 1
TYPICAL CROSS SECTION



OVERFLOW 1 - PROFILE VIEW



CUT/FILL		
COLOR	MIN. ELEVATION	MAX. ELEVATION
	-5.00	-4.00
	-4.00	-3.00
	-3.00	-2.00
	-2.00	-1.00
	-1.00	0.00
	0.00	1.00

ESTIMATED EARTHWORK VOLUMES FOR CONSTRUCTED CHANNEL	
CUT (CY)	90
FILL (CY)	0

LEGEND

- EXISTING GROUND
- DESIGN THALWEG
- CHANNEL STRUCTURE
- EXCAVATION

Geum Environmental Consulting
307 STATE ST.
HAMILTON, MT 59840
406.363.2353
geumconsulting.com

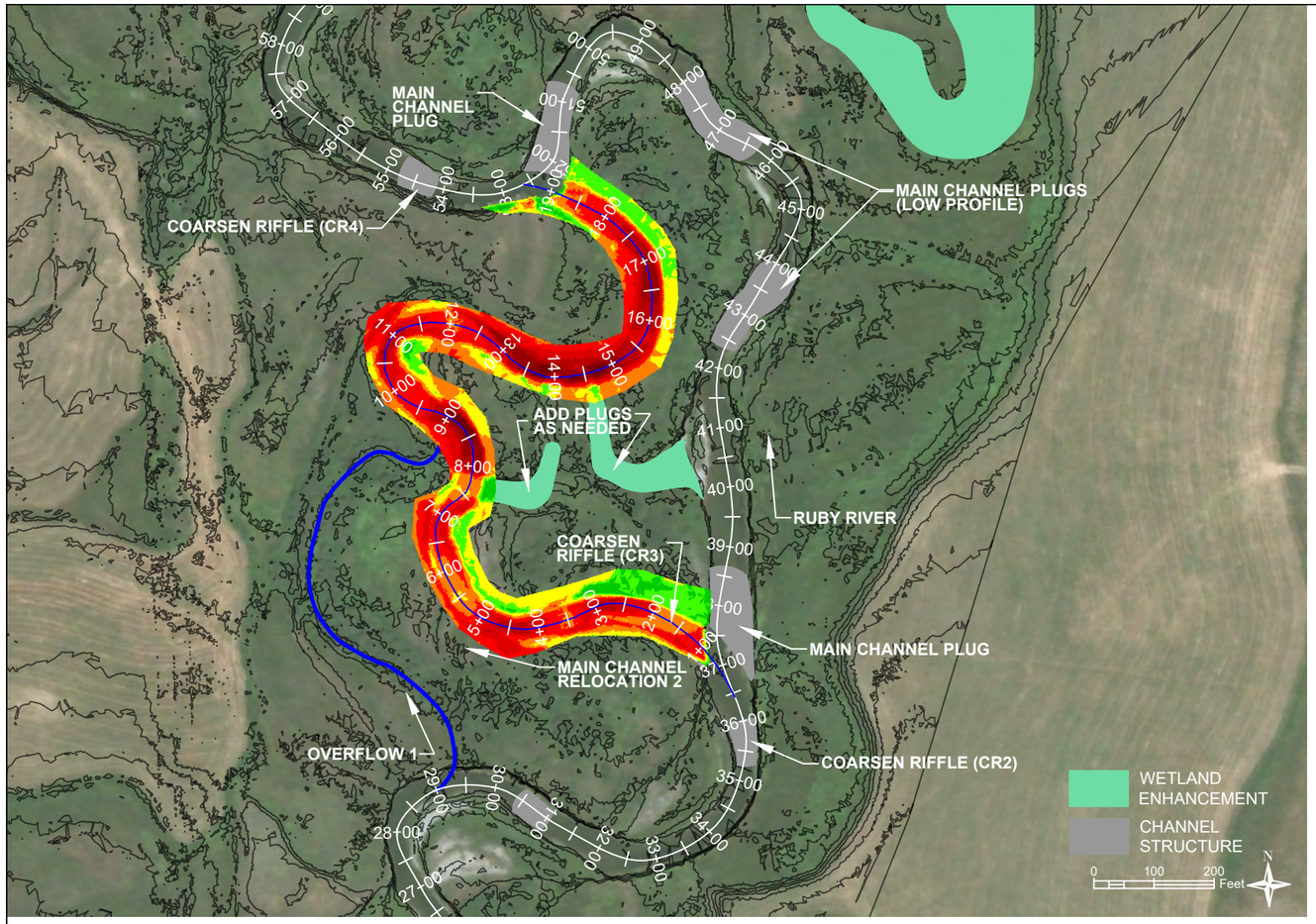
DATUM: North American Datum 1983
PROJECTION: Montana State Plane
UNITS: US Foot
DATA SOURCES: Digital Globe Imagery

ACTIVATION CHANNEL DETAILS
OVERFLOW 1 DETAILS

RUBY RIVER RVHA RESTORATION PROJECT
MADISON COUNTY, MONTANA

DRAWN BY: A.Gulley
DESIGNED BY: Geum, AGI, Gillilan
DATE: April 2021

SHEET
4.4



ACTIVATION CHANNEL DETAILS	
MAIN CHANNEL START STATION	37+00
MAIN CHANNEL END STATION	52+64
ACTIVATED CHANNEL LENGTH (FT)	N/A
CONSTRUCTED CHANNEL LENGTH* (FT)	1745
UPPER STRUCTURE HEIGHT (FT)	2.5
LOWER STRUCTURE HEIGHT (FT)	N/A
TARGET INLET ELEVATION (FT)	5425.5
TARGET OUTLET ELEVATION (FT)	5421.0
ACTIVATION STAGE ABOVE BED (FT)	0.0
ACTIVATION Q (CFS)	0
DAYS PER YEAR ACTIVATED	365
SLOPE	(ON PROFILE)
UPSTREAM MAIN CHANNEL PLUG ELEVATION	5428.0
DOWNSTREAM MAIN CHANNEL PLUG ELEVATION	5422.4
COARSEN RIFFLE STRUCTURE CR2 ELEVATION	5425.8
COARSEN RIFFLE STRUCTURE CR3 ELEVATION	5425.5
COARSEN RIFFLE STRUCTURE CR4 ELEVATION	5419.9

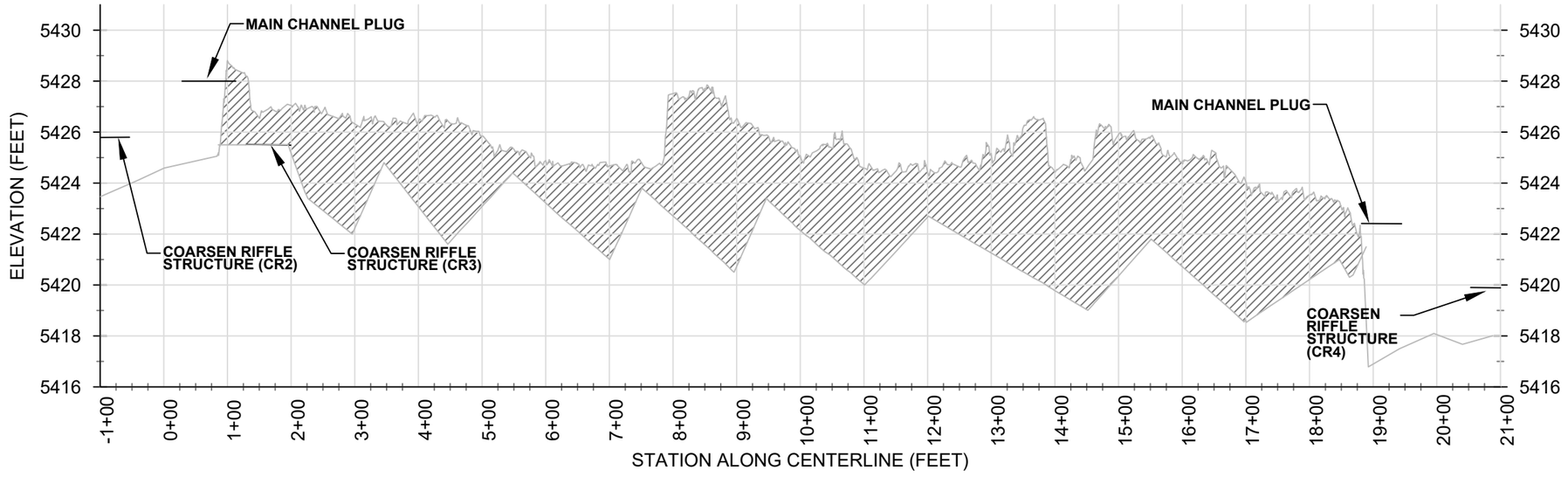
*TYPICAL CROSS SECTION DISPLAYED ON SHEET 3.2

LEGEND

- EXISTING GROUND
- DESIGN THALWEG
- CHANNEL STRUCTURE
- EXCAVATION

ESTIMATED EARTHWORK VOLUMES FOR CONSTRUCTED CHANNEL	
CUT (CY)	12855
FILL (CY)	500

MAIN CHANNEL RELOCATION 2 - PROFILE VIEW



CUT/FILL		
COLOR	MIN. ELEVATION	MAX. ELEVATION
	-7.00	-6.00
	-6.00	-5.00
	-5.00	-4.00
	-4.00	-3.00
	-3.00	-2.00
	-2.00	-1.00
	-1.00	0.00
	0.00	1.00
	1.00	2.00
	2.00	3.00
	3.00	4.00

Geum Environmental Consulting
307 STATE ST.
HAMILTON, MT 59840
406.363.2353
geumconsulting.com

DATUM: North American Datum 1983

PROJECTION: Montana State Plane

UNITS: US Foot

DATA SOURCES: Digital Globe Imagery

ACTIVATION CHANNEL MAIN CHANNEL RELOCATION 2 DETAILS

RUBY RIVER RVHA RESTORATION PROJECT
MADISON COUNTY, MONTANA

DRAWN BY: A.Gulley

DESIGNED BY: Geum, AGI, GIllilan

DATE: April 2021

SHEET
4.5