May 2011 Photo of Ryegate, MT - Kestrel Aerial

Musselshell River Floodplain Study – Phase II

Hydraulic Analysis and Floodplain Mapping

Golden Valley County

January 2017

Contract Number: WO-MM-143
Mapping Activity Statement No. 2015-12

Musselshell River Floodplain Study – Phase II

Hydraulic Analysis and Floodplain Mapping Report

Golden Valley County, MT

PREPARED FOR:

Montana Department of Natural Resources and Conservation

Federal Emergency Management Agency

January 13, 2017

PREPARD BY:

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I hereby certify that all work products (maps, reports, etc.) prepared for this project were done so under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Montana

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1.0 Introduction and Background

Morrison-Maierle, Inc. has completed a hydraulic analysis of the Musselshell River within Golden Valley County, Montana, as part of the Flood Risk Project initiated by the Montana Department of Natural Resources and Conservation (DNRC) in partnership with the Federal Emergency Management Agency (FEMA). The purpose of this report is to document the hydraulic analysis, and to provide results for incorporation into floodplain mapping and a Flood Insurance Study (FIS).

Most severe flooding events in this watershed have been produced from spring snowmelt and runoff from intense rainfall events. In May 2011 and March 2014, significant flooding occurred in the Musselshell River basin, appreciably exceeding previous peak floods of record.

The study limits, as shown on Figure 1, consists of three segments, Reach 2, Reach 7, and Reach 8. Three reaches out of 10 reaches to be studied in the overall contract. Reach 2 begins at the Golden Valley County eastern boundary and extends upstream approximately 51.6 river miles to the Golden Valley County western boundary. Reach 7 is within Reach 2 and begins near the east boundary of the community of Lavina and extends 5.7 river miles upstream of the western boundary of Lavina. Reach 8 is also within Reach 2 and begins near the east boundary of the community of Ryegate and extends 2.2 river miles upstream of the Ryegate western boundary.

Reach 2 revises approximately 11.2 river miles of Zone A and create 32.4 river miles of limited detail floodplain for a previously unmapped reach of the Musselshell River. Detailed study methods for Reaches 7 and 8, update the effective Zone AE and A floodplains for the towns of Lavina and Ryegate, respectively.

This Summary Report presents the information and methods used to develop the 1-percent-annual-chance (100-year) and 0.2-percent-annual-chance (500-year) floodplains. This study is based on the best available information including LIDAR, bathometric, structure survey, and a new hydrologic analysis developed specifically for this mapping update. The LIDAR was obtained by Photo Science Inc. in 2012 (Photo Science, 2012). The hydrologic analysis was completed by Pioneer Technical Services, Inc. in 2015 (Pioneer, 2015a) and approved by FEMA in 2015. Reach 2 hydraulic structure assessment was completed by Pioneer Technical Services, Inc. in 2015 (Pioneer, 2015b). Reaches 7 and 8 structure survey was completed by Morrison-Maierle, Inc. in the fall of 2015 (MMI, 2015) and submitted to FEMA in January 2016.

The hydraulic analysis for Musselshell River in Golden Valley County, Montana is summarized in this report. The flood study includes the 10%, 4%, 2%, 1%, and 0.2% annual-chance flood events. FEMA Standards (SID# 84) for Flood Risk Projects identify a requirement to model a 1-percent plus in riverine analyses and include the 1-percent plus in the Flood Profiles for the FIS Report. Discussions between DNRC and FEMA removed this requirement from the Mapping Activity Statement (MAS 2015-02) for the Musselshell Watershed Project, Phase II. Thus, no 1-percent plus hydrologic or hydraulic analyses were

performed as part of this study and no flood profiles will be presented for 1-percent plus in the FIS.

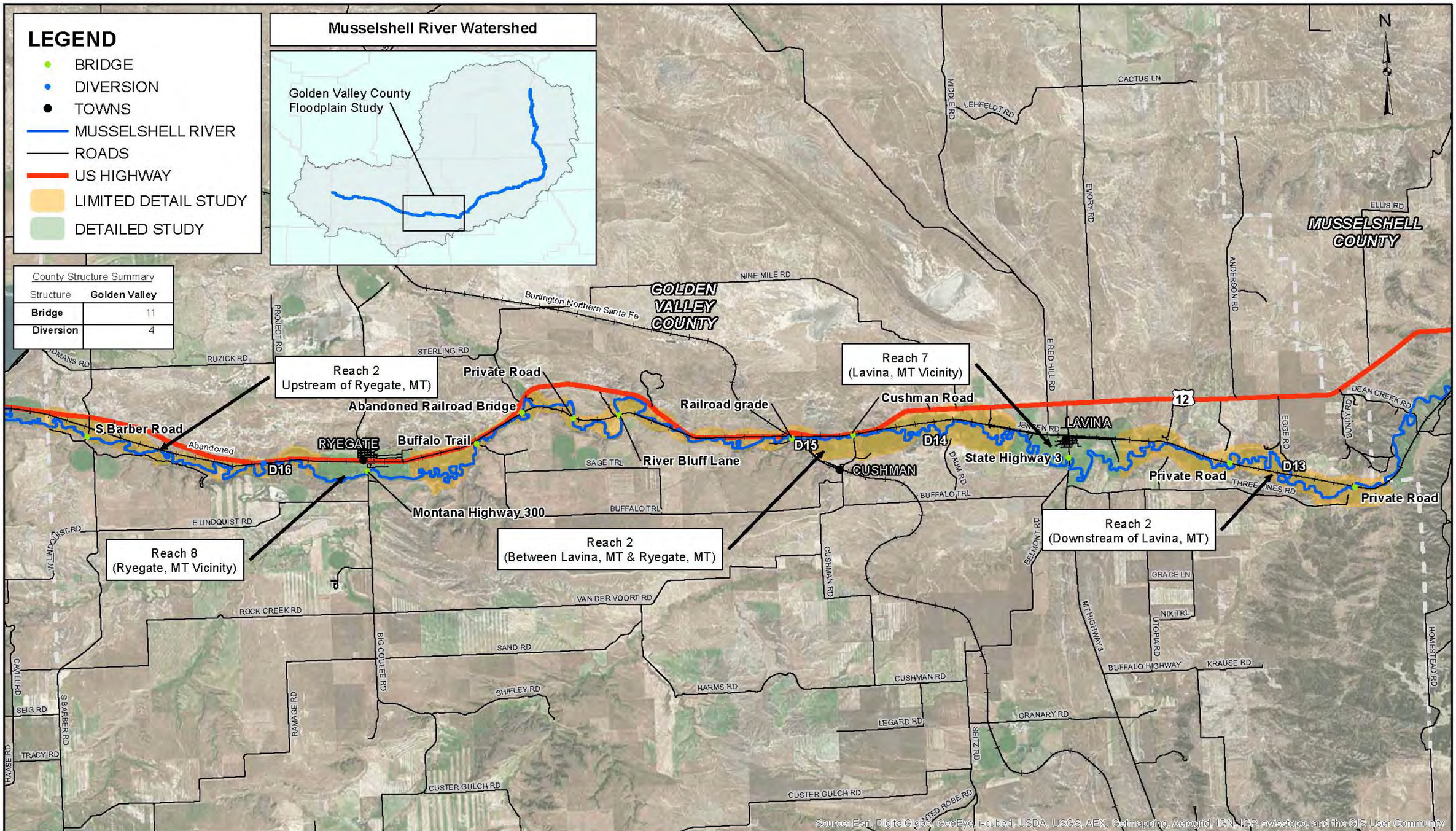
The Montana Department of Natural Resources (DNRC) and the professional service contractor Morrison-Maierle, Inc. (MMI) have completed this study using guidelines and standards published in the FEMA Resource and Document Library to ensure the study complies with the National Flood Insurance Program.

1.1 Watershed Description

The Musselshell River is located east of the continental divide in central Montana and originates in the Castle, Little Belt, and Crazy Mountains. The mainstem Musselshell River begins at the confluence of the North Fork and South Fork of the Musselshell Rivers near the town of Martinsdale, Montana and flows to the east and then north for approximately 335 miles to its confluence with the Missouri River and Fort Peck Reservoir. The entire Musselshell watershed area encompasses approximately 9,471 square miles (Pioneer, 2015).

Elevations in the Musselshell River basin range from approximately 9,000-feet in the Crazy Mountains to approximately 2,000-feet at the confluence with the Missouri River (Pioneer, 2015). The terrain varies from a high alpine environment in its headwaters to a prairie landscape in the eastern reaches with expansive grass and shrub lands, broken and rolling foothills, and low density drainage networks (Applied Geomorphology and RATT, 2012). The hydrology of the basin is primarily snowmelt driven although significant flows can result from summer precipitation events.

Land use in the Musselshell River basin is primarily agricultural with irrigated and dryland farming and ranching operations. Most of the intensely farmed land is located within the Musselshell River floodplain. Three irrigation storage reservoirs exist on the Musselshell: the Bair Reservoir on the North Fork; Martinsdale Reservoir an off-stream reservoir fed by the South Fork Musselshell River near Martinsdale; and Deadman's Basin Reservoir an off-stream reservoir between Shawmut and Ryegate. Martinsdale Reservoir and Deadman's Reservoir do not provide any flood protection due to their limited feeder canal capacity (Pioneer, 2015). Bair Reservoir is located in the headwaters of the North Fork Musselshell River and does not provide significant flood protection for the mainstem Musselshell River due to its limited capacity. During the summer and fall seasons, reaches of the Musselshell River are often dewatered due to irrigation withdrawals.



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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Golden Valley County MT

Study Limits

PROJECT NO. 1447.041

FIG. 1

2.0 Previous Mapping

Flood Insurance Rate Maps (FIRMs) were completed for Golden Valley County with an effective date of September 16, 1981. The flood hazards currently mapped for the Musselshell River is Zone A for approximately 11.2-miles within Golden Valley County. Zone AE mapping is available for 5.7-miles within the town of Lavina and Zone A mapping is available for 2.2-miles within the town of Ryegate.

Zone A is a special flood hazard zone without detailed hydraulic modeling and base flood elevations. Zone AE is a special flood hazard zone with detailed hydraulic modeling and base flood elevations. This floodplain study will change the flood zones on the maps to Zone AE for Golden Valley County.

3.0 Hydrology

This detailed flood study, as shown on Figure 1, covers approximately 51.6 river miles of the Musselshell River within Golden Valley County. The beginning of the study is at river mile zero at the Golden Valley County eastern boundary and extending upstream to approximately river mile 51.6 at the county's western boundary. One active and two inactive United States Geological Survey (USGS) gaging station are located in the vicinity of the study area. The active gage (06123030 Musselshell River above Mud Creek near Shawmut, Montana) is approximately four miles east of Shawmut along Hwy 12 and has been in operation since 1998. Figure 2 identifies the gaging station locations and the summary data for the gages are listed in Table 1.

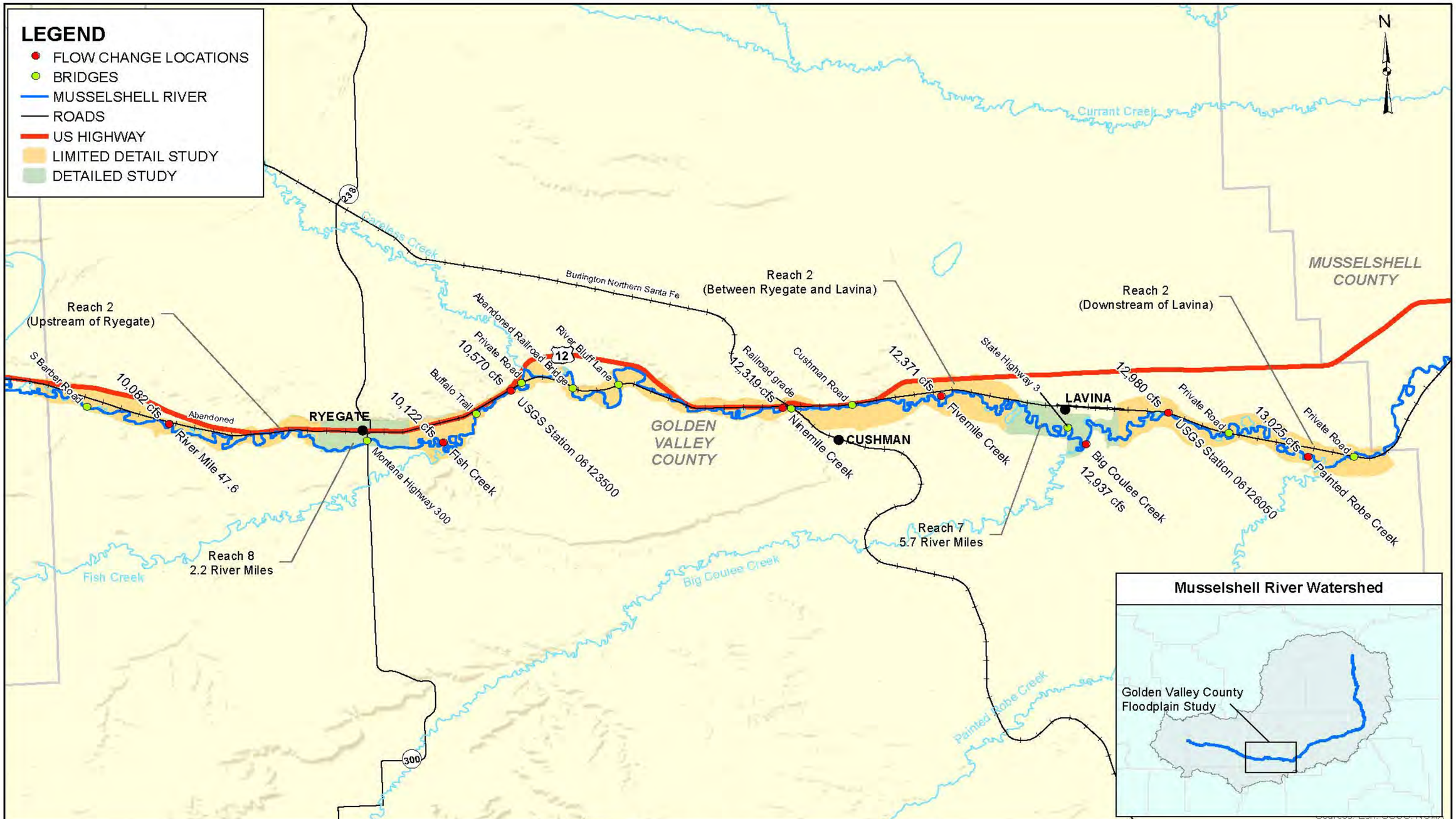
Table 1. USGS Gaging Stations

Gaging Station Number	Gaging Station Name	Period of Record	Number of Annual Peaks	Drainage Area (square miles)	Maximum Peak Discharge (cfs) / Year	Minimum Peak Discharge (cfs) / Year
06126050	Musselshell River near Lavina	1992 - 2011	20	2,947	14,500 / 2011	372 / 2002
06123500	Musselshell River near Ryegate	1947 - 1979	33	1,957	9,500 / 1967	175 / 1977
06123030	Musselshell River above Mud Creek, near Shawmut	1998 - 2015	18	1,518	8,900 / 2011	72 / 2000

The hydrologic analyses included flood frequency analysis following the Interagency Advisory Committee on Water Data, Bulletin #17B (USGS, 1982b). Systematic flood frequency analyses were completed for 11 gages on the Musselshell River shown per USGS WRIR 03-4308 (Parrett & Johnson, 2004) and based on extended gage records to the year 2014 (Pioneer, 2015).

To accurately model the Musselshell River, locations of major tributary confluences and other flow change locations were identified in the hydrologic analyses (Pioneer, 2015). The peak flow frequency estimates at the ungaged flow change locations were calculated using the drainage area gage transfer method and two site logarithmic interpolation methods in accordance with USGS WRIR 03-4308 (Parrett & Johnson, 2004).

The summary of peak flow estimates at the USGS gaged and ungaged locations for the Musselshell River in Golden Valley County are presented in Table 2 and the 1% annual-chance flow change locations are shown on Figure 2.



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Golden Valley County MT

MUSSELSHELL RIVER FLOW CHANGE LOCATIONS

PROJECT NO. 1447.041

FIG. 2

Table 2. Summary of Discharges for Musselshell River

River Station	HEC-RAS Model Segment	Location Description	Peak Flow Rate (cfs)				
			10% Annual Chance (10-year)	4% Annual Chance (25-year)	2% Annual Chance (50-year)	1% Annual Chance (100-year)	0.2% Annual Chance (500-year)
9703	Reach 2A	Painted Robe Creek	4,567	7,257	9,852	13,025	23,242
43556	↓	USGS Station 06126050	4,561	7,241	9,824	12,980	23,130
56369	↓	Big Coulee Creek	4,551	7,222	9,795	12,937	23,032
66409	Reach 7	Big Coulee Creek	4,551	7,222	9,795	12,937	23,032
87270	↓	Fivemile Creek	4,421	6,974	9,413	12,371	21,751
105201	Reach 2B	Fivemile Creek	4,421	6,974	9,413	12,371	21,751
127583	↓	Ninemile Creek	4,409	6,951	9,378	12,319	21,636
180749	↓	USGS Station 06123500	3,991	6,167	8,184	10,570	17,790
197724	↓	Fish Creek	3,619	5,799	7,798	10,122	16,889
208498	↓	River Mile 47.6	3,586	5,766	7,763	10,082	16,809
220611	Reach 8	River Mile 47.6	3,586	5,766	7,763	10,082	16,809
251402	Reach 2C	River Mile 47.6	3,586	5,766	7,763	10,082	16,809
272397	↓	USGS Station 06123030	3,495	5,673	7,665	9,968	16,580

4.0 Hydraulics

The methods and techniques used to complete the hydraulic analysis of the Musselshell River in Golden Valley County are presented in the following sections. The limited detail for the Reach 2 analysis utilized the LiDAR mapping and hydraulic structure assessment to develop 1% and 0.2% AC Zone AE mapping without a floodway. The detailed analysis for Reaches 7 and 8 utilized the LiDAR mapping, bathymetric surveys, and hydraulic structure surveys to develop 1% and 0.2% AC Zone AE mapping and 1% AC floodway.

4.1 Hydraulic Analysis

This floodplain study of the Musselshell River within Golden Valley County, Montana consists of three segments, Reach 2, Reach 7, and Reach 8. The limited detail analysis of Reach 2 begins at the Golden Valley County east boundary and extending upstream approximately 51.6 river miles to the Golden Valley western boundary. The detailed analysis of Reach 7 begins near the east boundary of the community of Lavina and extends 5.7 river miles upstream of the western boundary of Lavina. The detailed analysis of Reach 8 begins near the east boundary of the community of Ryegate and extends 2.2 river miles upstream of the Ryegate western boundary. The reaches are shown on Figure 1 and length of each segment is summarized in Table 3.

The HEC-RAS model for Reach 2 was set up into three segments. Reach 2A model extends from the eastern Golden Valley County boundary to the town of Lavina. Reach 2B model extends from the town of Lavina to the town of Ryegate. Reach 2C model extends from the town of Ryegate to the western Golden Valley County boundary.

Table 3. Reach Segment Summary

Segment	Starting River Mile	Ending River Mile	Length (River Miles)
Reach 2A	0.0	10.7	10.7
Reach 7	10.7	16.4	5.7
Reach 2B	16.4	39.5	23.1
Reach 8	39.5	41.7	2.2
Reach 2C	41.7	51.6	9.9
		Total	51.6

Appendix C of FEMA Guidelines and Specifications (FEMA 2009) were followed for the hydraulic model development. The water surface elevations (WSEL's) were calculated with HEC-RAS, Version 4.1.0 hydraulic modeling software (USACE 2010a). HEC-RAS for steady flow analysis performs the standard step energy balance calculation between cross sections starting at the most downstream cross section and moving upstream for a fully subcritical analysis.

Cross sections were placed with GeoHECRAS hydraulic computer modeling software (GeoHECRAS, 2016) at flow distances or reach lengths ranging from approximately 100- to 1,000-feet and at structure locations along the floodplain.

4.2 Topographic Data Acquisition

The Natural Resource Conservation Service (NRCS) contracted with Photo Sciences to acquire topographic Light Detection and Ranging (LiDAR) data for the project area in 2012. The LiDAR deliverables included 1-meter grid bare earth digital elevation models (DEM) for the entire length of the Musselshell River corridor (NRCS, 2012). The LiDAR data was collected with the following specifications:

Projection:	Montana State Plane	Units
Datum:	Horizontal – NAD83	International Feet
	Vertical – NAVD88	US Feet

NAD: North American Datum
NAVD: North American Vertical Datum

4.3 Profile Baseline

The stream channel centerline for Reaches 2, 7, and 8 of the Musselshell River was utilized to define the Profile Baseline of river stationing as stream distance in feet above the respective downstream limit. The profile baseline is shown on the Work Maps included in Appendix A. The stream centerlines (Profile Baselines) were created using the LiDAR and National Agricultural Imagery Program (NAIP) aerial imagery (USDA, 2012). The summary of key features along each reach of the Musselshell River for Reaches 2, 7, and 8 are presented in Tables 4, 5, and 6, respectively.

Table 4. Key Features along Reach 2 Profile Baseline

River Station	Feature	Description	1% AC Discharge (cfs)
0	Downstream Limit of Study	Furthest downstream cross section near Musselshell River Mile 0.	13,025
4750	Private Road	Structure B23 – two span steel structure and wood deck bridge with a total span of approximately 182-feet.	13,025
9703	Flow Change Location	Painted Robe Creek confluence with Musselshell River.	13,025
21378	Diversion location	Diversion D13 – concrete construction with a total span of approximately 95-feet.	12,980
34266	Private Road	Structure B24 – two span steel structure and wood deck bridge with a total span of approximately 164-feet.	12,980
43556	Flow Change Location	USGS stream gage 06126050 – Musselshell River near Lavina.	12,980
56369	Upstream Limit Reach 2A	End of Model Reach 2A near Musselshell River Mile 10.8.	12,937
87270	Downstream Limit Reach 2B	Beginning of Model Reach 2B near Musselshell River Mile 16.5.	12,371
105201	Flow Change Location	Fivemile Creek confluence with Musselshell River.	12,371
108680	Diversion location	Diversion D14 – concrete construction with a total span of approximately 120-feet.	12,319
119394	Cushman Road	Structure B26 – clear span concrete bridge with a total span of approximately 119-feet.	12,319
126669	Burlington Northern Santa Fe Railroad Bridge	Structure B27 – Bridge east abutment cross section.	12,319
126692		Structure B27 – Skewed concrete bridge pier cross section #1.	12,319
126736		Structure B27 – Skewed concrete bridge pier cross section #2.	12,319
126786		Structure B27 – Skewed concrete bridge pier cross section #3.	12,319
126856		Structure B27 – Skewed concrete bridge pier cross section #4.	12,319
126901		Structure B27 – Skewed concrete bridge pier cross section #5.	12,319
126952		Structure B27 – Skewed concrete bridge pier cross section #6.	12,319
126995		Structure B27 – Skewed concrete bridge pier cross section #7.	12,319
127059		Structure B27 – Skewed concrete bridge pier cross section #8.	12,319
127134		Structure B27 – Skewed concrete bridge pier cross section #9.	12,319
127205		Structure B27 – Skewed concrete bridge pier cross section #10.	12,319
127205		Diversion D15 – concrete construction with a total span of approximately 153-feet.	12,319
127287		Structure B27 – Bridge east abutment cross section.	12,319
127583	Flow Change Location	Ninemile Creek confluence with Musselshell River.	12,319

Table 4 (cont.) Key Features along Reach 2 Profile Baseline

River Station	Feature	Description	1% AC Discharge (cfs)
156388	Private Crossing	Structure B28 – Facility washed out during 2011 flood event and not included in model.	10,570
157583	River Bluff Lane	Structure B29 – two span steel structure with a total span of approximately 122-feet.	10,570
168319	Private Road	Structure B30 – two span steel structure with a total span of approximately 160-feet.	10,570
177997	Abandon Railroad Bridge	Structure B31 – two span steel structure and wood deck bridge with a total span of approximately 164-feet.	10,570
180749	Flow Change Location	USGS stream gage 06123500 – Musselshell River near Ryegate.	10,570
187234	Buffalo Trail	Structure B32 – clear span steel truss bridge with a total span of approximately 168-feet.	10,122
197724	Flow Change Location	Fish Creek confluence with Musselshell River.	10,122
208498	Upstream Limit Reach 2B	End of Model Reach 2B near Musselshell River Mile 39.5.	10,082
220611	Downstream Limit Reach 2C	Beginning of Model Reach 2C near Musselshell River Mile 41.7.	10,082
231144	Diversion location	Diversion D15 – rock construction with a total span of approximately 76-feet.	10,082
251402	Flow Change Location	River Mile 47.6.	10,082
265062	S Barber Road	Structure B34 – clear span concrete bridge with a total span of approximately 119-feet.	9,968
272397	Upstream Limit of Study	Furthest upstream cross section near Musselshell River Mile 51.5.	9,968

Table 5. Key Features along Reach 7 Profile Baseline

River Station (feet)	Feature	Description	1% AC Discharge (cfs)
56369	Downstream Limit of Study	Furthest downstream cross section near Musselshell River Mile 10.6.	12,937
66409	Flow Change Location	Big Coulee Creek confluence with Musselshell River.	12,937
72493	State Highway 3	Structure B25 – three span concrete bridge with a total span of 145-feet.	12,371
87270	Upstream Limit of Study	Furthest upstream cross section near Musselshell River Mile 16.5.	12,371

Table 6. Key Features along Reach 8 Profile Baseline

River Station (feet)	Feature	Description	1% AC Discharge (cfs)
208498	Downstream Limit of Study	Furthest downstream cross section near Musselshell River Mile 39.5.	10,082
	MT Highway 300	Structure B33 – two span concrete bridge with a total span of 144-feet.	10,082
220611	Upstream limit of study	Furthest upstream cross section near Musselshell River Mile 41.7.	10,082

4.4 Boundary Conditions

To perform the hydraulic analysis, HEC-RAS requires boundary condition input data at the first downstream cross section of the model reach. According to FEMA Guidelines and Specifications, Appendix C (FEMA, 2009), the downstream boundary condition in a one-dimensional, steady flow, step-backwater model should be taken from a previously established water-surface elevation. The boundary condition established water-surface elevation for Golden Valley County Reach 2A was taken from the upstream Musselshell River model reach of Musselshell County as part of the Mapping Activity Statement (MAS 2015-02) for the Musselshell Watershed Project, Phase II.

A summary of the boundary condition established for each model segment for Golden Valley County is provided in Table 7.

Table 7. Boundary Condition Summary

Segment	Water Surface Elevation Model Source
Reach 2A	Musselshell County Reach 1C
Reach 7	Golden Valley County Reach 2A
Reach 2B	Golden Valley County Reach 7
Reach 8	Golden Valley County Reach 2B
Reach 2C	Golden Valley County Reach 8

4.5 Cross Section Development

The terrain data in the GeoHECRAS (GeoHECRAS, 2016) model was predominately based on the aforementioned LiDAR data. Utilizing the GIS computer program ArcMap 10.1 (ESRI, 2012), cross sections were placed perpendicular to flow and along estimated equipotential lines. End points for all cross sections were established as required to capture the boundaries of the 0.2-percent annual-chance floodplain. Cross sections were placed at key locations along the reach including: breaks in channel slope, abrupt changes in floodplain width, and at bridge and diversion structure locations. Cross sections were filtered to less than 500 points per cross section as required by HEC-RAS.

The LiDAR elevation data for the limited detail study reach 2 did not include bathymetry below the water surface. However, the LiDAR data represents the water surface elevation of the river at the time the data was obtained. A rectangular low-flow channel was inserted in the model and the computed water surface elevation was calibrated to the LiDAR elevation data by adjusting channel depths. The calibration goal was to achieve a computed water surface elevation within +/- 0.5 feet of the observed LiDAR elevation

The detailed study Reaches 7 and 8 include stream channel bathymetry survey completed by Morrison-Maierle, Inc. in 2015 and was combined with LiDAR using GeoHECRAS ‘Conflate Point Data’ tool to replace the LiDAR data with the stream channel bathymetry survey. Cross sections were filtered to less than 500 points per cross section as required by HEC-RAS. The cross sections are shown on the Hydraulic Work Maps provided in Appendix A.

4.6 Hydraulic Structure

A field reconnaissance and hydraulic structure assessment for the Musselshell River limited detail study Reach 2 was performed by Pioneer Technical Services, Inc. in 2015 (Pioneer, 2015a). The geometries of hydraulic structures were modeled with the data obtained from the structures assessment. Eleven bridge and four diversion structures exist within the study limits. The structures range from abandon railroad bridges to structures on county and private roadways. Diversion structures deliver water to irrigation districts or private water user associations. Five of the bridge crossings remain from the historic Milwaukee Road Railroad which was decommissioned in the 1970's.

The field survey for hydraulic structures for the Musselshell River detail study Reaches 7 and 8 was completed by Morrison-Maierle, Inc. in 2015. The survey included hydraulic structures located at State Highway 3 in Lavina and Montana Highway 300 in Ryegate for Reaches 7 and 8, respectively.

The geometry for the hydraulic structures were modeled with the data obtained from the structure assessment and survey. The expansion and contraction coefficients of the two upstream cross sections along with the one downstream cross sections at the bridge constrictions were increased from the natural channel value of 0.1 and 0.3, to 0.3 and 0.5, respectively. This hydraulic modeling practice was made to account for the increased head loss associated with the relatively abrupt transitions and varying velocities that accompany the expansion and contraction of flows at a bridge.

The bridge modeling approach is set for both high and low flow methods based on the bridge configuration. The high flow methods consist of either the Energy (Standard Step) or Pressure/Weir flow. The Energy method is the standard step calculation method and is utilized when the bridge low chord has freeboard and/or if the road approaching the bridge is lower and the bridge is perched above the approach road. The Pressure/Weir flow method is the high flow method that is used when flood waters impact and/or overtop the bridge structure.

The low flow methods include either the Energy, Momentum or Yarnell methodologies. The energy method is utilized if the bridge is a clear span structure with no piers. The Momentum Balance and Yarnell equation methods are used if the structure is constructed with mid-span piers. The Momentum and Yarnell methods are low flow methods to account for the hydraulic losses due to water moving around the piers. The momentum method requires an input for the Drag Coefficient (CD), and the Yarnell equation using a K Coefficient based on the pier shape.

The pier shape for the bridge structures in Golden Valley County consist of piers with a triangular nose and 90 degree angle ends (TN90). The CD and K coefficients used for this pier shape are 1.33 and 1.05, respectively.

A summary of the bridge structures and hydraulic model settings for each structure are summarized in Tables 8 and 9, respectively. Photographs 1 thru 3 are of representative abandoned railroad, highway, and county road bridge structures. Photographs of all the modeled bridge structures are provided in Appendix C.

Photograph 1: Abandon Railroad Bridge B23 with Triangular Nose with 90° Angle Piers.

Photograph 2: MT Highway 3 Bridge B25 with Triangular Nose with 90° Angle Piers.

Photograph 3: Cushman Road Clear Span Bridge B26 with No Piers.

4.7 Burlington Northern Santa Fe Railroad Structure

The Burlington Northern Santa Fe (BNSF) Railroad Structure located along Reach 2 consists of a twelve span structure at an approximate skew angle of 45-degrees, as shown on photographs 4 and 5. Due to the number of piers at a skew, the structure was modeled with independent cross sections located at each pier location. The blocked area option in HEC-RAS was utilized to model the 5-foot wide piers at a 45-degree angle. This technique models how each pier independently restricts flow and creates a backwater condition versus all piers being impacted simultaneously during a high flow event.

4.8 Hydraulic Modeling at Denied Access Structures

Pioneer Technical Services, Inc. was denied the access required to complete the structure assessment for three bridge structures located in Reach 2. The denied access included structures B28, B29, and B30. Structure B28 provided a bridge crossing to a private roadway and was washed out in the 2011 flood event and, therefore, this structure was not included in the hydraulic model. Structure B29 provides a river crossing at River Bluff Lane and Structure B30 provides a river crossing at a private road.

Photograph 4: Looking Downstream at BNSF Railroad Bridge B27.

Photograph 5: Looking Downstream at Left Overbank of BNSF Railroad Bridge B27.

Structures B29 and B30 are abandoned railroad bridges and survived the 2011 flood event. These two structures are included in the hydraulic model. The structures span length, width, and pier locations data was measured using the LiDAR data. The pier size, type, and deck thickness were set consistent with the upstream abandoned railroad bridge structure B31. Structure B31 is approximately 1.8- and 3.9-river miles upstream of structures B30 and B29, respectively.

Table 8. Summary of Bridge Structures

ID No.	Roadway	River Reach	River Station	Spans	Total Span (feet)	Deck Width (feet)	Deck Thickness (feet)	Pier Width (feet)	Appendix C Photo Pages
B23	Private Road	2	4750	2	182	10	4.3	6.0	1, 2, 3
B24	Private Road	2	34266	2	164	10	4.2	6.6	4, 5, 6
B25	State Highway 3	7	72493	3	145	30	3.9	3.0	7, 8, 9
B26	Cushman Road	2	119394	1	119	31.6	5.2	–	10, 11, 12
B27	Burlington Northern Santa Fe Railroad	2	126669 to 127287	12	782	15	8.3	5.0	13, 14, 15, 16, 17, 18
B29	River Bluff Lane	2	157583	2	122	10	2.7	6.0	19
B30	Private Road	2	168319	2	160	10	2.7	6.0	20
B31	Abandon Railroad	2	177997	2	164	10	2.7	6.0	21
B32	Buffalo Trail	2	187234	1	168	16.4	2.2	–	22, 23, 24
B33	MT Highway 300	8	208498	2	144	25.1	4.0	3.0	25, 26, 27
B34	S Barber Road	2	265062	1	119	26	5.0	–	28, 29, 30

Table 9. Summary of Bridge Model Settings

ID No.	Roadway	River Reach	River Station	Contraction Coefficient	Expansion Coefficient	Low Flow Method	High Flow Method
B23	Private Road	2	4750	0.3	0.5	Energy, Momentum, Yarnell	Pressure/Weir
B24	Private Road	2	34266	0.3	0.5	Energy, Momentum, Yarnell	Pressure/Weir
B25	State Highway 3	7	72493	0.3	0.5	Energy, Momentum, Yarnell	Pressure/Weir
B26	Cushman Road	2	119394	0.3	0.5	Energy	Pressure/Weir
B27	Burlington Northern Santa Fe Railroad	2	126669 to 127287	0.3	0.5	Energy	Energy
B29	River Bluff Lane	2	157583	0.3	0.5	Energy, Momentum, Yarnell	Pressure/Weir
B30	Private Road	2	168319	0.3	0.5	Energy, Momentum, Yarnell	Pressure/Weir
B31	Abandon Railroad	2	177997	0.3	0.5	Energy, Momentum, Yarnell	Pressure/Weir
B32	Buffalo Trail	2	187234	0.3	0.5	Energy	Pressure/Weir
B33	MT Highway 300	8	208498	0.3	0.5	Energy, Momentum, Yarnell	Energy
B34	S Barber Road	2	265062	0.3	0.5	Energy	Energy

4.9 Diversion Structures

The study reach includes four diversion structures used to create a backwater condition so that Musselshell River flow can be diverted into adjacent irrigation canals. These structures were modeled with the placement of one cross section at the location that represents the crest of the diversion and the second cross section downstream where the river channel returns to a normal depth and natural cross section. Table 10 is a summary of the diversion structures located along the Musselshell River in Golden Valley County. Photographs 6 and 7 are examples of concrete and rock diversions. Photographs of all the modeled diversion structures are provided in Appendix D.

Table 10. Summary of Diversion Structures

ID No.	River Reach	River Station	Material	Condition	Span (feet)	Appendix C Photo Pages
D13	2	21378	Concrete	Good	95	34, 35
D14	2	108680	Concrete	Good	120	36, 37
D15	2	127205	Concrete	Good	153	38, 39
D16	2	231144	Rock	Good	76	40, 41

Photograph 6: Diversion D15 Concrete Structure.

Photograph 7: Diversion D16 Rock Structure.

4.10 Manning's 'n' Values

Manning's 'n' values are roughness coefficients representing the frictional resistance acting on water when flowing overland or through a channel. The coefficients are used in the calculations to determine water surface elevations. Five land classes were developed for the study area to establish Manning's 'n' values based on ground and cover conditions. The land classes were developed through interpretations of aerial photographs and Montana Department of Revenue Land Classification Units. The classification work resulted in a spatial layer covering the study area. Manning's 'n' values assigned within the hydraulic model were determined based on field observation, aerial photography, land-use mapping and the USGS publication, 'Guide to Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains' (USGS, 1982).

The USGS guide was used to develop minimum, maximum, and initial Manning's 'n' values for each land class. The initial land class Manning's 'n' values were assigned to the spatial land classification data set and the GeoHECRAS application was used to assign the spatial based roughness data to the cross-sections in the model.

Manning's 'n' values were evaluated at each cross-section in GeoHECRAS and adjustments to the horizontal limits were made to fit with the terrain data represented by the cross section. Adjustments to the Manning's 'n' values were also made as needed during hydraulic model development. The adjustments to the Manning's 'n' value remained within the range of acceptable values determined for each land class. Manning's 'n' values used in the study are provided in Table 11.

Table 11: Manning's 'n' Values

Roughness Area Land Class Type	Manning's 'n' Value	Description
Main Channel	0.039 – 0.055	Coarse gravel
Grass/Hay & Herbaceous Meadow	0.058 – 0.090	Normal/Native valley vegetation
Agricultural Cropped Area	0.060	Cropped & cultivated areas
Riparian Cottonwood & Willow	0.070	Heavy willow and cottonwood growth
Medium Dense Trees	0.080	Stands of timber, few down trees

4.11 Areas of Non-Conveyance

As indicated on the Hydraulic Work Maps in Appendix A, there are reaches where no flow or backwater conditions exist. This conditions provide limited or non-conveyance in the downstream direction. For these areas, the ineffective Flow Area Method was implemented to model and calculate the total effective conveyance for each cross section. Review of the modeled cross sections in HEC-RAS identified depression areas that are not hydraulically connected to the stream body. These areas were also classified as ineffective flow areas in order for the model to correctly calculate the appropriate conveyance at the cross section.

Areas of flow expansion and contraction at the cross sections bounding structures were also assigned areas of non-conveyance in order to direct the one-dimensional steady state model to calculate the head loss due to two-dimensional flow contraction and expansion. The flow contraction and expansion areas were calculated in a stream wise to lateral direction using a 1:1 and a 4:1 ratio, respectively. The ratios of expansion and contraction were developed using the cross sectional velocities as recommended in the HEC-RAS Reference Manual (USCOE 2010).

The associated ineffective flow descriptions have been placed in the HEC-RAS text box for each cross section to document the non-conveyance areas implemented for the hydraulic model. The types of non-conveyance included the following:

- Backwater and ponded areas.
- Flow constriction or expansion.
- Areas isolated by non-accredited levees, abandoned railroad embankments or elevated roads.
- High topography either upstream or downstream that limits flow to a lower area.

4.12 Model Calibration

The model calibration for reaches 2, 7, and 8 were completed with the NAIP imagery taken during the high water event which occurred on May 2011. The peak flow rate of 14,500 cfs was recorded at USGS gage 06126050 Musselshell River near Lavina, Montana on May 25, 2011. A comparison of the 1% annual-chance water surface elevations (WSE's) from the HEC-RAS model were directly compared to the photographs because the flow rate at the time the aerials were taken was representative of a 1% annual-chance event.

The comparison of WSE's was done at river stations in straight river segments away from structures, since they represent relatively uniform flow conditions without the local hydraulic influence from structures. The differences in WSE's was estimated by observing the extents

of the high water on the NAIP imagery and comparing to the contour information from the LiDAR mapping. The differences in the Reach 2 model ranged from minimum of 0.0-feet to a maximum of 0.9-feet. The differences in Reach 7 model, ranged from minimum of 0.0-feet to a maximum of 0.9-feet. The differences in Reach 8 model, ranged from minimum of 0.4-feet to a maximum of 0.9-feet. Based on the differences in Tables 12, 13, and 14, the HEC-RAS modeling is reasonably calibrated for the purposes of a floodplain study by the comparison to water surfaces elevations from a known event.

Table 12. Reach 2 Model Calibration

River Station	Appx. WSE 2011 NAIP Imagery (feet)	Modeled WSE (feet)	Difference (feet)
2539	3,359.0	3,358.6	0.4
6835	3,365.5	3,365.1	0.4
133080	3,519.5	3,519.0	0.5
138125	3,524.0	3,524.9	0.9
141634	3,533.0	3,533.1	0.1
144485	3,536.0	3,536.4	0.4
191415	3,605.0	3,605.0	0.0
245416	3,686.0	3,686.2	0.2
255149	3,703.0	3,703.6	0.6

Table 13. Reach 7 Model Calibration

River Station	Appx. WSE 2011 NAIP Imagery (feet)	Modeled WSE (feet)	Difference (feet)
58028	3,420.0	3,419.8	0.2
60911	3,422.0	3,421.7	0.3
62859	3,424.0	3,424.0	0.0
65297	3,425.0	3,425.3	0.3
77966	3,436.0	3,435.3	0.7
80256	3,437.5	3,436.6	0.9
83578	3,439.0	3,439.1	0.1

Table 14. Reach 8 Model Calibration

River Station	Appx. WSE 2011 NAIP Imagery (feet)	Modeled WSE (feet)	Difference (feet)
205547	3,621.0	3,620.1	0.9
208498	3,623.0	3,623.8	0.8
209025	3,627.0	3,626.5	0.5
210147	3,629.5	3,628.7	0.8
212075	3,632.5	3,633.3	0.8
214497	3,640.0	3,640.4	0.4

4.13 Floodways

Floodways were computed for the Musselshell River detailed study Reaches 7 and 8 at each cross section. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections and are presented in the Floodway Data Tables in Appendix D. The work maps show only the floodway boundary, in cases where the floodway and 1% annual-chance floodplain are either close together or collinear.

In Montana, the designated floodway is developed using a 0.5-foot surcharge instead of the Federal maximum of 1.0-foot (DNRC, 2014). These criteria take precedence over the minimum Federal criteria for purposes of regulating development in the floodplain, as set forth in the Code of Federal Regulations, 24 CFR, 1910 (d).

It is not technically possible to have a full 0.5-feet of surcharge allowance at all cross sections. The 0.5-foot allowance is a maximum limit that cannot be exceeded at any cross section throughout the study reach. The equal conveyance reduction method of floodway modeling may produce a surcharge at an upstream cross section that exceeds the 0.5-foot maximum limit. Therefore, some cross sections, as shown in the Floodway Data Table, have surcharges of less than the 0.5-foot maximum allowable limit because of the effect that a greater encroachment at these locations would have on adjacent cross sections.

4.14 cHECk-RAS

FEMA's automated review software cHECk-RAS, Version 2.0.1 (FEMA, 2011) was utilized to verify the acceptability of the hydraulic analyses described above. The computer program checks five categories:

- NT (Manning's roughness coefficients and transition loss coefficients)
- XS (Cross sections)
- Floodways
- Structures
- Profiles

The cHECk-RAS output messages for the Golden Valley County reach of the Musselshell River were reviewed and each issue was either resolved or investigated and confirmed that the modeling was correct. Appendix E includes the list of cHECk-RAS messages and responses to each message.

5.0 Floodplain Mapping

Floodplain mapping was prepared using ESRI ArcMap 10.1 (ESRI, 2012) and HEC-GeoRAS 10.1 toolbar (USACR, 2009). HEC-GeoRAS determines the floodplain area by intersecting the LiDAR Digital Elevation Model (NRCS, 2012) with a separate Digital Elevation Model (DEM) representing the water surface elevations of the 1% and 0.2% annual-chance events. The results of the hydraulic modelling and topographic data are used to create products for end users that are described in the following sections.

5.1 Floodplain Work Maps

The resulting floodplains for the 1% and 0.2% annual-chance flood events are displayed on the hydraulic work maps provided in Appendix A. The base map used for the hydraulic work map is the 2012 NAIP aerial photograph. Along with the flooding extents, the work map also displays the stream profile baseline along with the cross sections utilized during the hydraulic analysis. The layout of the cross sections and structures under existing conditions are presented on the work maps.

Typically, islands that were determined to be higher than the adjacent 1% annual-chance water surface profile and less than one-acre in size were not delineated. Large backwater areas that extended through multiple cross sections were also modified to represent the elevation associated with the location where the backwater initiates from the man channel. These two adjustments provide a slight variance in the mapped widths versus the top widths described by the HEC-RAS mode at selected locations. A table of the 1% AC and 0.2% AC backwater elevations and the corresponding profile baseline station is included in Table 14 below.

Table 15. Backwater Elevation Summary

River Station	River Reach	1% AC	0.2% AC	County
8944	2	3368.2	3370.5	Golden Valley
10310	2	3368.9	3371.3	Golden Valley
52820	2	3414.8	3416.9	Golden Valley
59170	7	3420.3	3422	Golden Valley
62824	7	3424	3426.3	Golden Valley
67459	7	3428.5	3429.6	Golden Valley
198536	2	3614.5	3415.3	Golden Valley

The floodplain and floodway delineations at residential structure locations are based on local topographic grading and associated Base Flood Elevations (BFE's). In Reach 7 and Reach 8 no residential structures were mapped out of the floodway.

5.2 Map Tie-In Locations

There are no map tie-in locations, since this is the first floodplain study for the Musselshell River in Golden Valley County, Montana.

5.3 Changes Since Last FIRM Mapping

The proposed physical map revision based on these analyses results in significant changes to the floodplain and floodway boundaries. These changes are a result of technological improvements in modeling and mapping, better detailed topographic information, and other factors which overall, and better represent current conditions in the area. The sections below describe and present select output illustrating these Changes Since Last FIRM (CSLF).

5.4 One-Percent Annual Chance (SFHA) Boundary

A very useful set of output from the proposed floodplain mapping for Golden Valley County along the Musselshell River are a series of work maps that visually represent areas of the SFHA that have changed under the proposed hydraulic analysis and mapping. This information can be used by community officials and Golden Valley County staff to assess the implications of the changes, aid in outreach and education, provide information for planning and mitigation activities, communicate updated flood risk to residents, and other uses. The CSLF work maps for the one-percent annual chance boundary are provided in Appendix G.

5.5 Letters of Map Change

A review was made of the Letters of Map Change (LOMC) along the Musselshell River within the study area to identify locations where previously issued LOMC may need to be considered in the context of the changes proposed by this updated study. This review identified no effective Letters of Map Change (LOMC) for the Musselshell River in Golden Valley County, Montana.

5.6 Floodplain Boundary Standard Audit

The Floodplain Boundary Standard (FBS) audit is a process to provide reliable and defendable flood hazard mapping to incorporate into the FIRM. The FBS audit verifies that the floodplain delineations are accurate by comparing the water surface elevations generated by the hydraulic modeling to the best available terrain data. For this study, the water surface elevations were created using the best available terrain data and the results met the criteria in SID 113. However, the process necessarily lends itself to exceptions based on several factors. These exceptions can be attributed to issues associated with a confluence, tributary, or backwater areas, and around hydraulic structures. The FBS self-certification forms are included with the QA/QC documentation for this study.

5.7 Depth Grids

Flood depth grids have been created for the 10-, 4-, 2-, 1-, and 0.2-percent-annual chance flood events to show the inundation depths at these flood frequencies throughout the

mapped floodplain. The flood depth grids are a tool that communities can use to identify, prepare, and evaluate actions that can be taken to reduce flood risk. The flood depth grids are included in the digital datasets that accompany this report.

6.0 Flood Insurance Study Products

Digital profiles for the 10%, 4%, 2%, 1%, and 0.2% annual-chance water surface elevations were created using FEMA's RASPLOT software (FEMA 2013). Additional information, edits and formatting were made using AutoCAD. Profiles were developed following Appendix J, Section J.2.2 of FEMA Guidelines and Specifications (FEMA 2003). The profiles illustrating the results of the study are provided in Appendix B.

FEMA Standards (SID# 84) for Flood Risk Projects identify a requirement to model a 1-percent plus in riverine analyses and include the 1-percent plus in the Flood Profiles for the FIS Report. Discussions between DNRC and FEMA removed this requirement from the Mapping Activity Statement (MAS 2015-02) for the Musselshell Watershed Project, Phase II.

7.0 References

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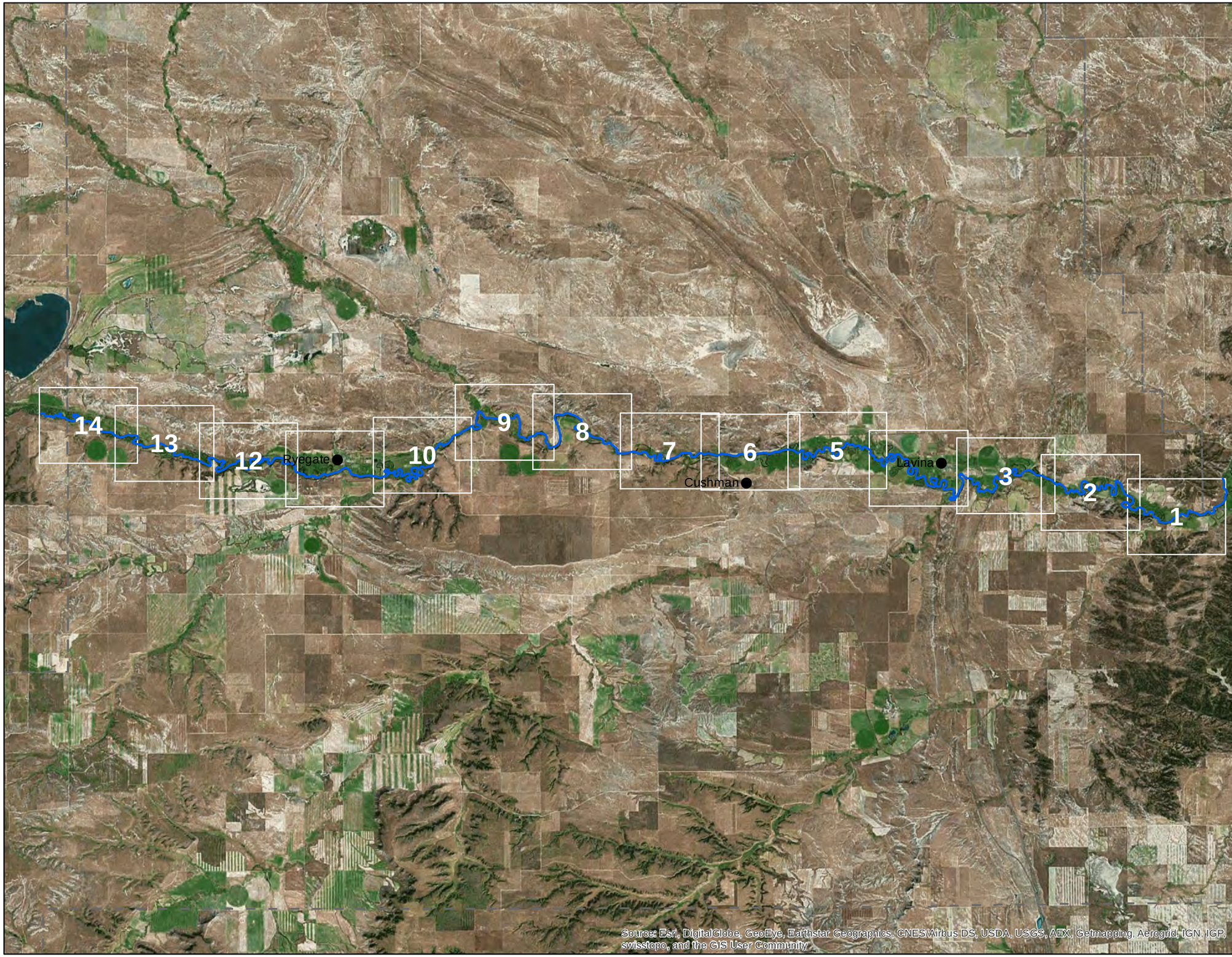
APPENDICES

Appendix A – Hydraulic Work Maps

- Reach 2
- Reach 7
- Reach 8



GOLDEN VALLEY COUNTY MUSSELSHELL RIVER FLOODPLAIN WORKMAP INDEX

LEGEND
- Towns
- Musselshell River
- Golden Valley Workmap Panels
- County Boundary

Labels
- A Cross Section Letter 79,726 River Station
- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

0 6,250 12,500 18,750 Feet

Work Map Index - Musselshell Watershed Project - Ph. II
Golden Valley County, MT Risk MAP - MAS No. 2015-02
NAIP 2013, Horizontal Datum: NAD83
Topographic Data, LiDAR 2012
Hozontal Datum: NAD83, Vertical Datum: NAVD88, Feet
Submitted 1/13/2017

MONTANA DNRC

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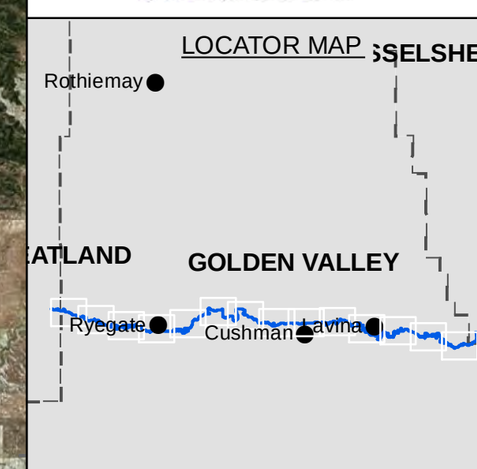
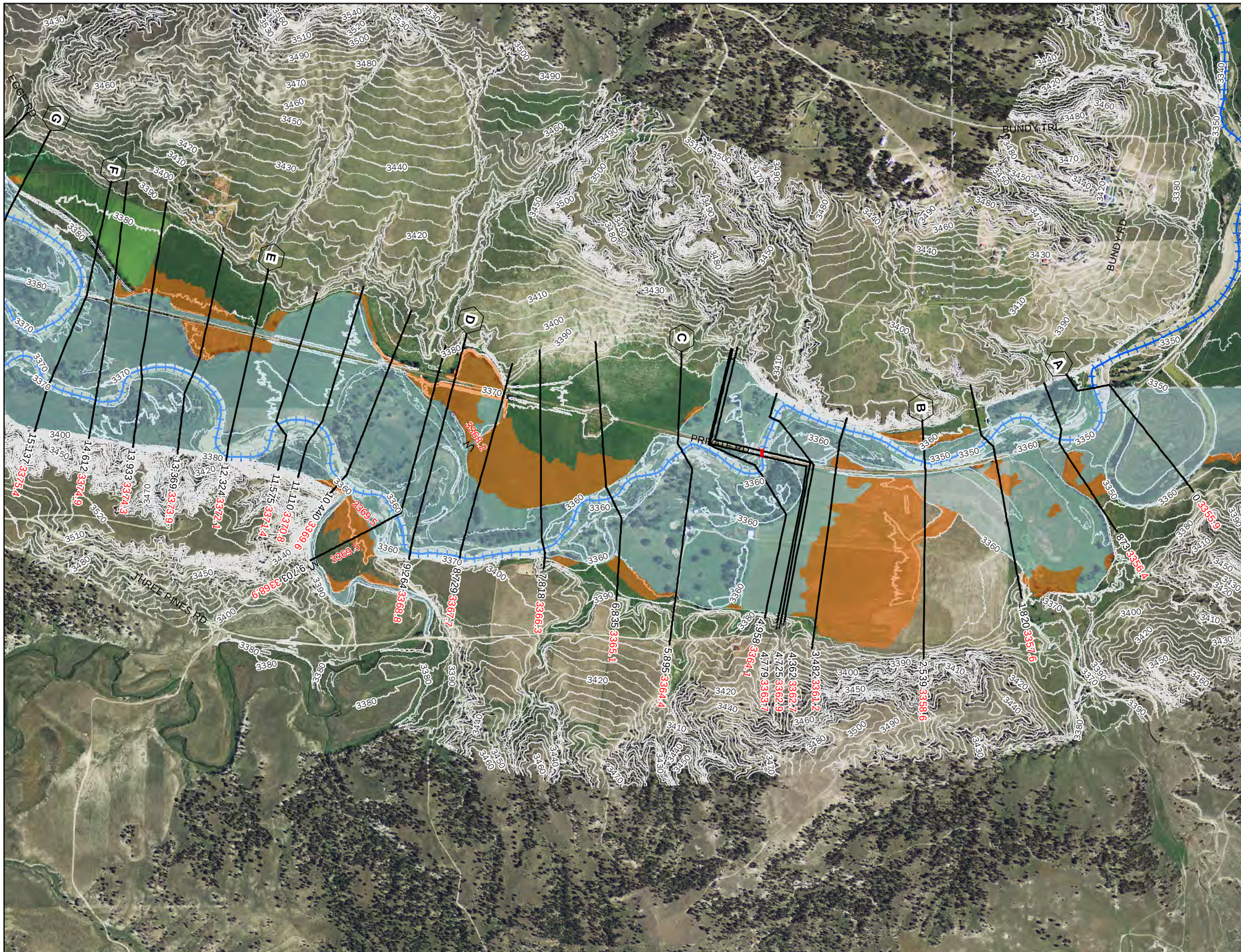
Morrison Maierle
engineers · surveyors · planners · scientists

LOCATOR MAP



Musselshell River Index Map



GOLDEN VALLEY COUNTY TOPOGRAPHIC WORKMAP

LEGEND

- Roadway Crossings
- Musselshell River
- 10' Contour
- 5' Contour
- Backwater BFE

Proposed Flood Hazard Area

- 0.2% AC
- AE - 1% AC
- FLOODWAY
- County
- City Limits

Labels

- A Cross Section Letter
- 79,726 River Station
- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

0 500 1,000 1,500 Feet

Hydraulic Work Map - Musselshell Watershed Project - Ph. II
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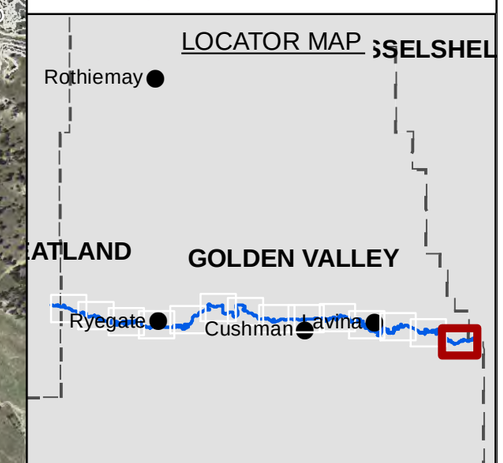
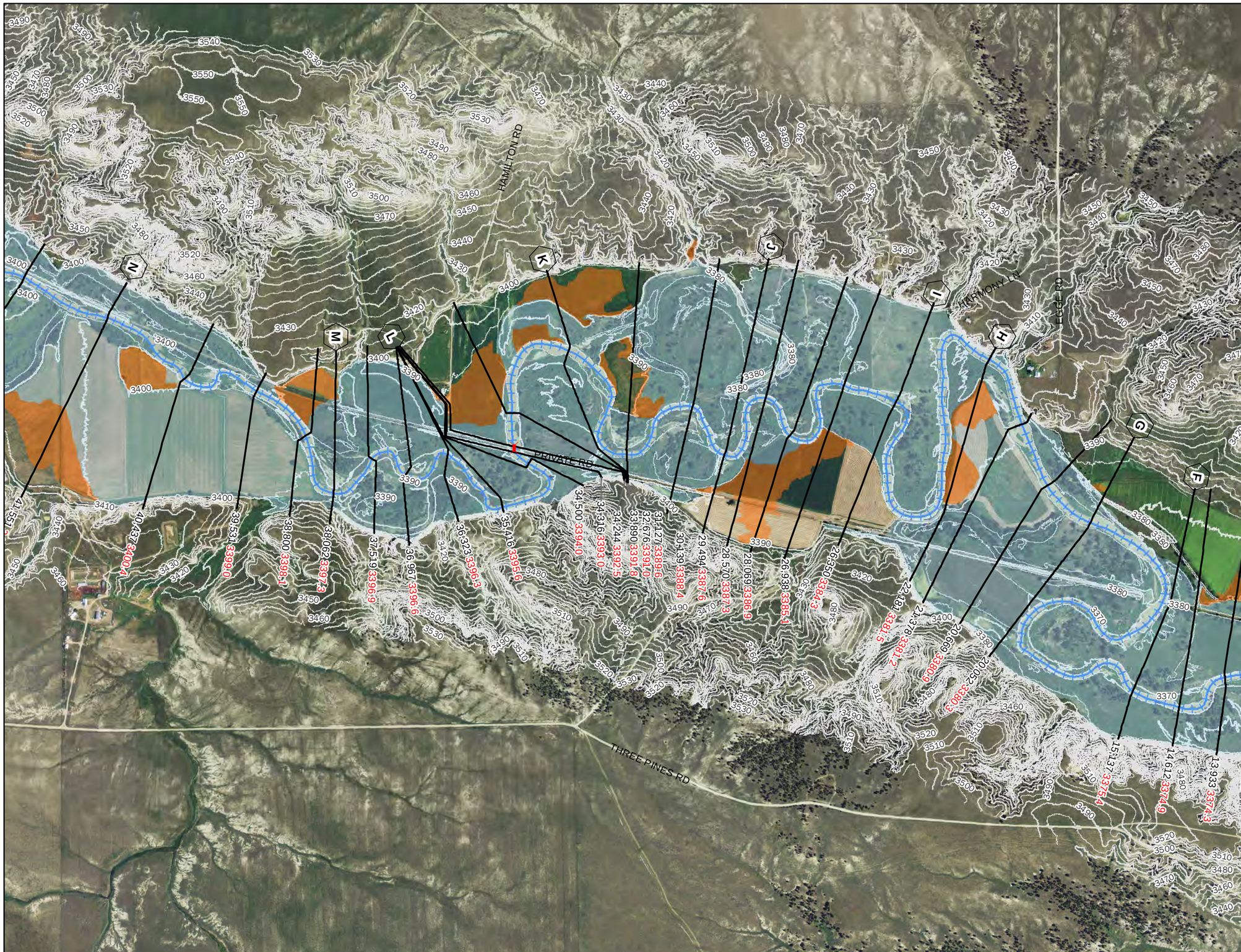


Musselshell River Map 1 of 14

GOLDEN VALLEY COUNTY TOPOGRAPHIC WORKMAP



LEGEND

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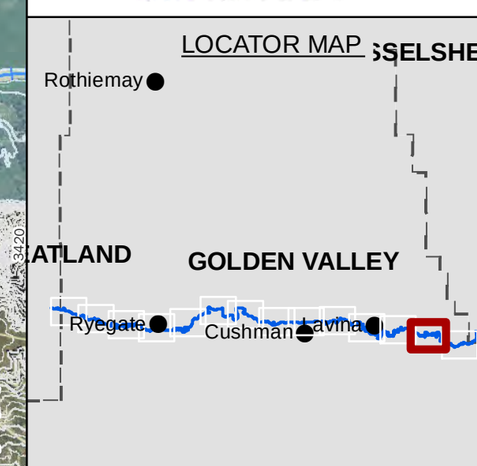
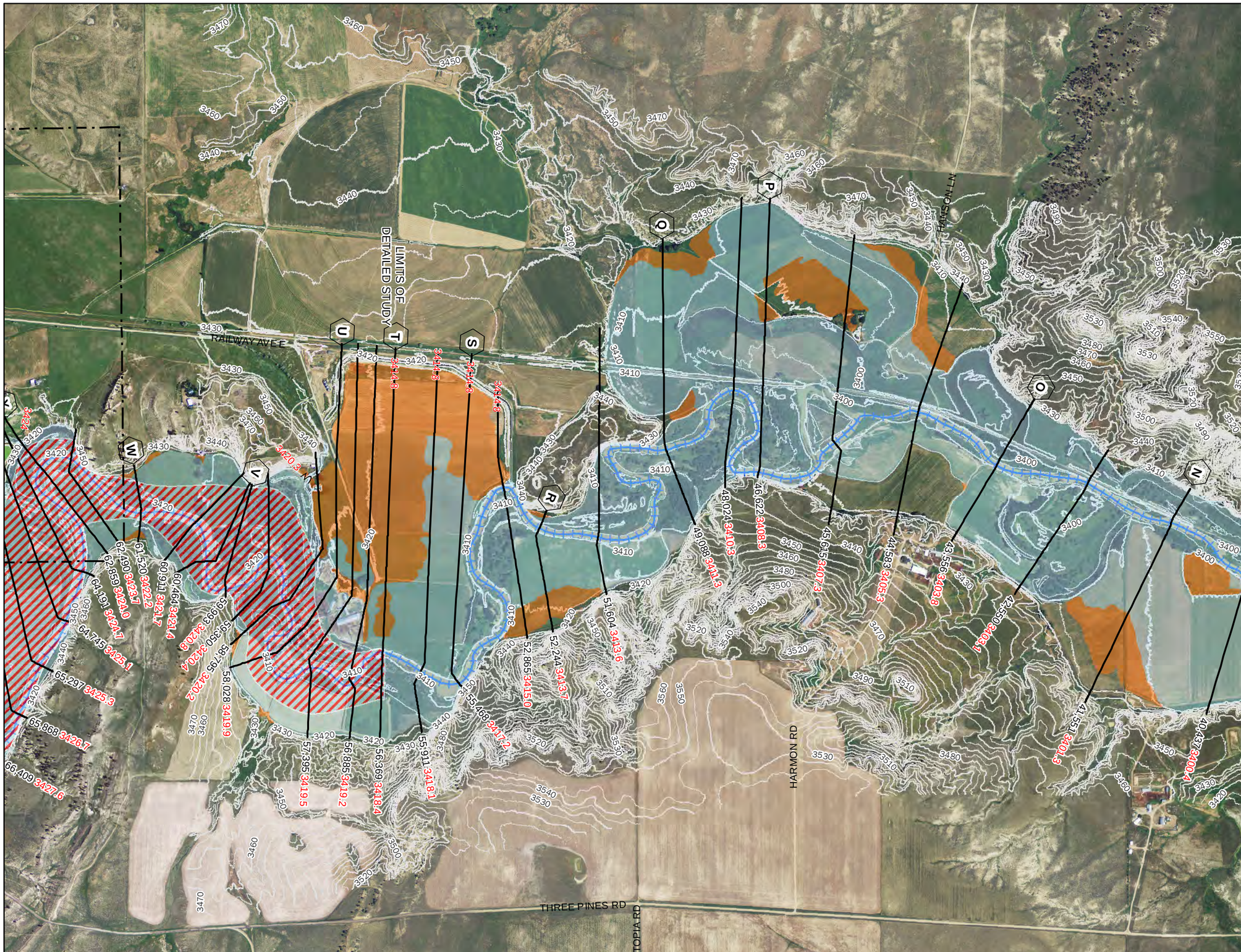


Musselshell River Map 2 of 14



GOLDEN VALLEY COUNTY TOPOGRAPHIC WORKMAP

LEGEND

- Roadway Crossings
- Musselshell River
- 10' Contour
- 5' Contour
- Backwater BFE

Proposed Flood Hazard Area

- 0.2% AC
- AE - 1% AC
- FLOODWAY
- County
- City Limits

Labels

- (A) Cross Section Letter — 79,726 River Station
- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

0 500 1,000 1,500 Feet

Hydraulic Work Map - Musselshell Watershed Project - Ph. II
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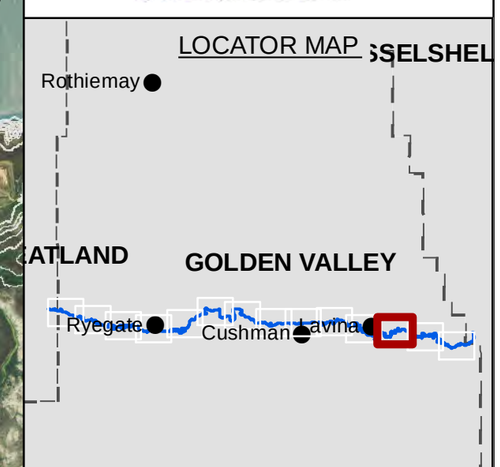
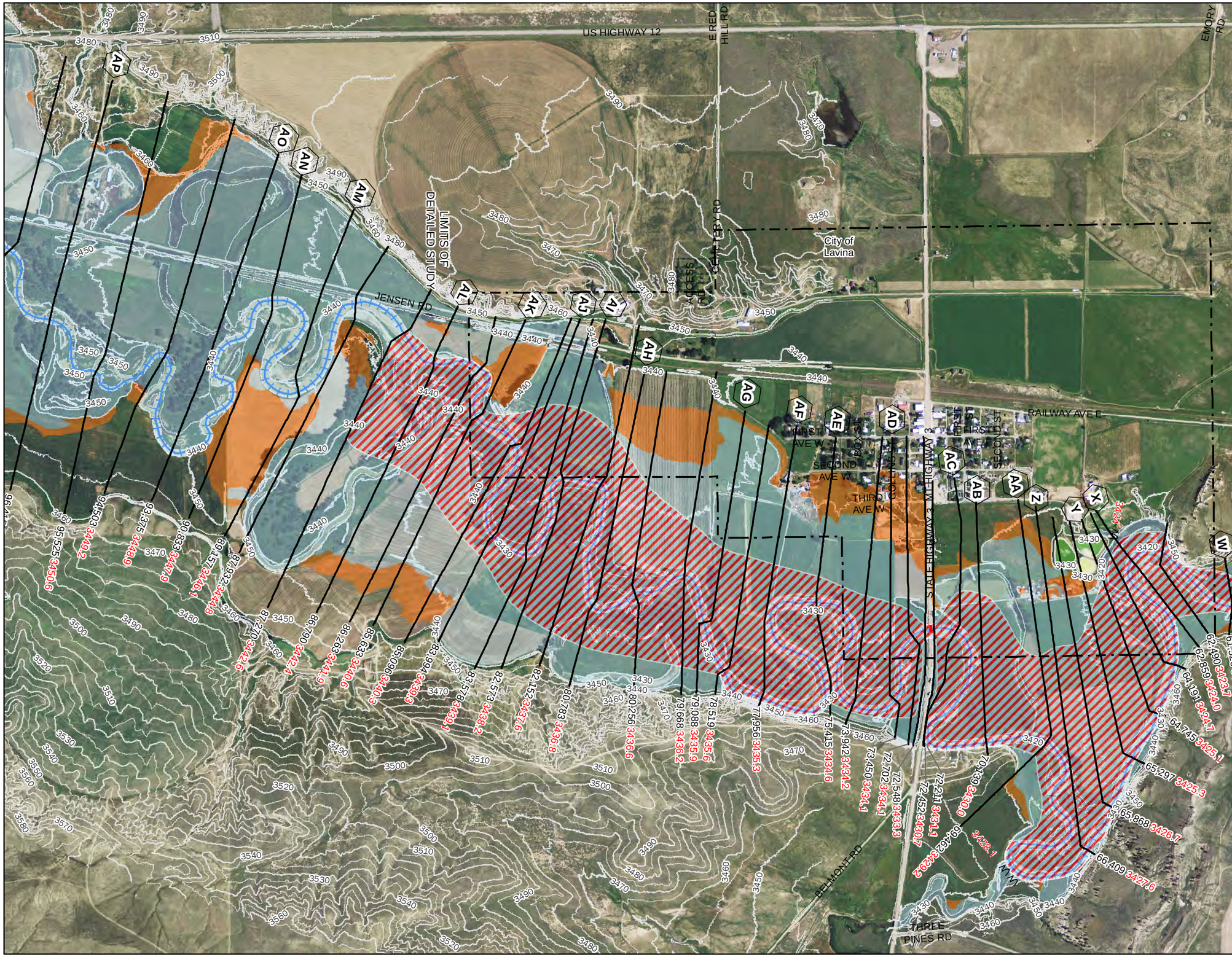
LOCATOR MAP



Musselshell River Map 3 of 14



GOLDEN VALLEY COUNTY TOPOGRAPHIC WORKMAP

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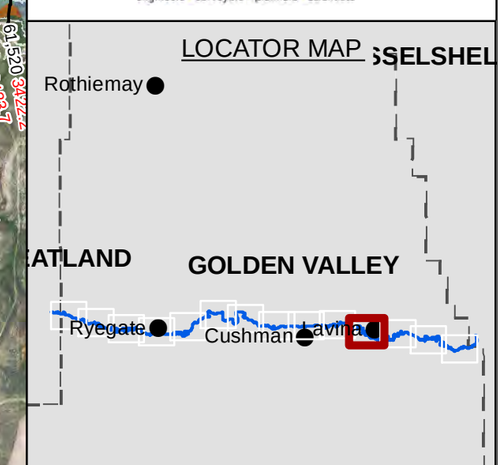
MONTANA DNRC

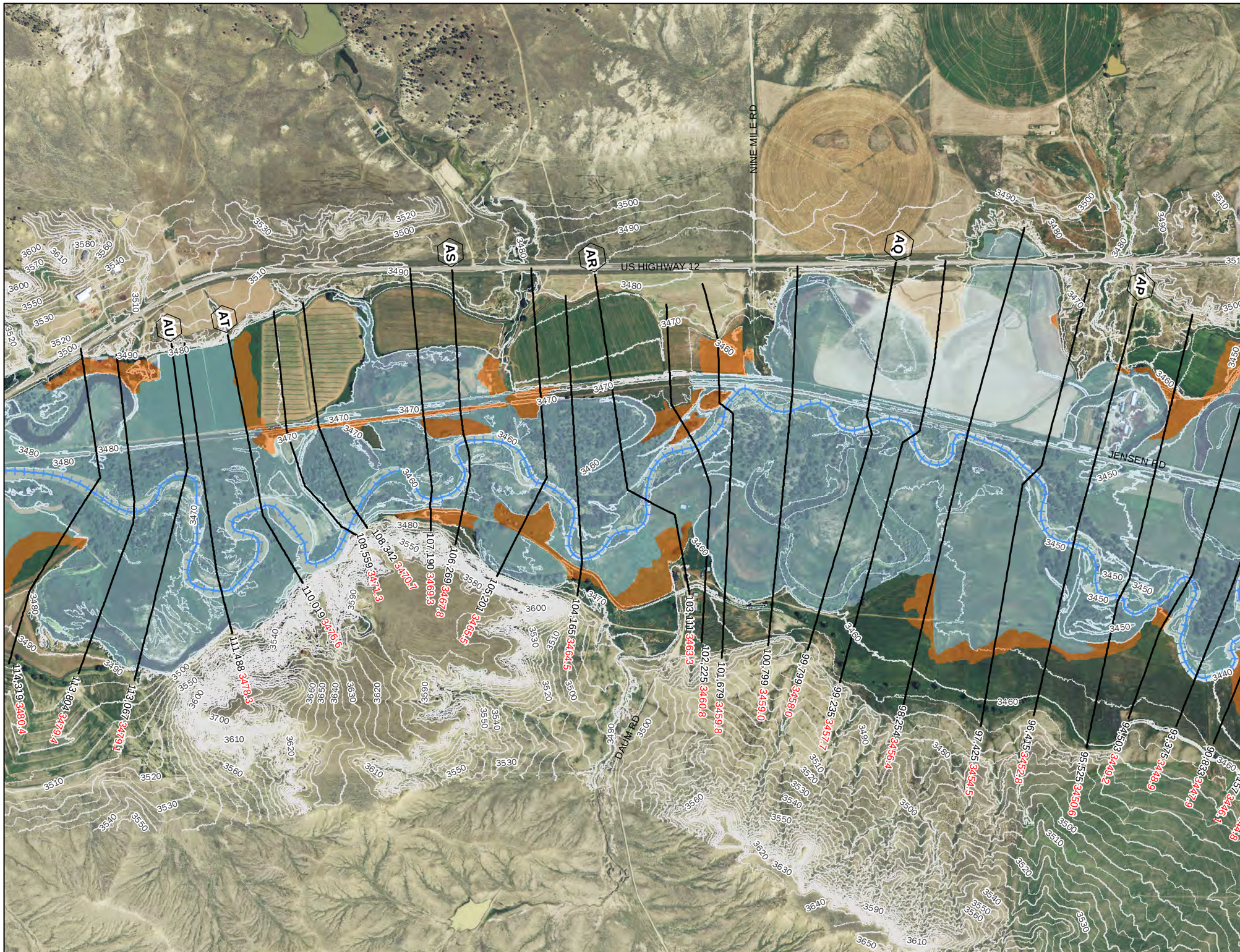
THE OFFICIAL SEAL OF GOLDEN VALLEY COUNTY STATE OF MONTANA

Morrison Maierle
engineers · surveyors · planners · scientists

LOCATOR MAP



Musselshell River Map 4 of 14



GOLDEN VALLEY COUNTY TOPOGRAPHIC WORKMAP

LEGEND

- Roadway Crossings
- Musselshell River
- 10' Contour
- 5' Contour
- Backwater BFE

Proposed Flood Hazard Area

- 0.2% AC
- AE - 1% AC
- FLOODWAY
- County
- City Limits

Labels

- A Cross Section Letter — 79,726 River Station
- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

0 500 1,000 1,500 Feet

Hydraulic Work Map - Musselshell Watershed Project - Ph. II
Golden Valley County, MT Risk MAP - MAS No. 2015-02
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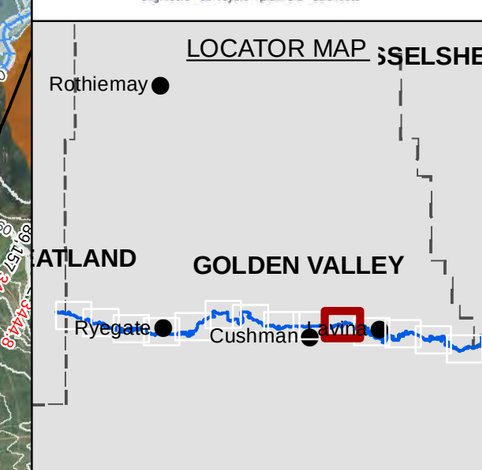
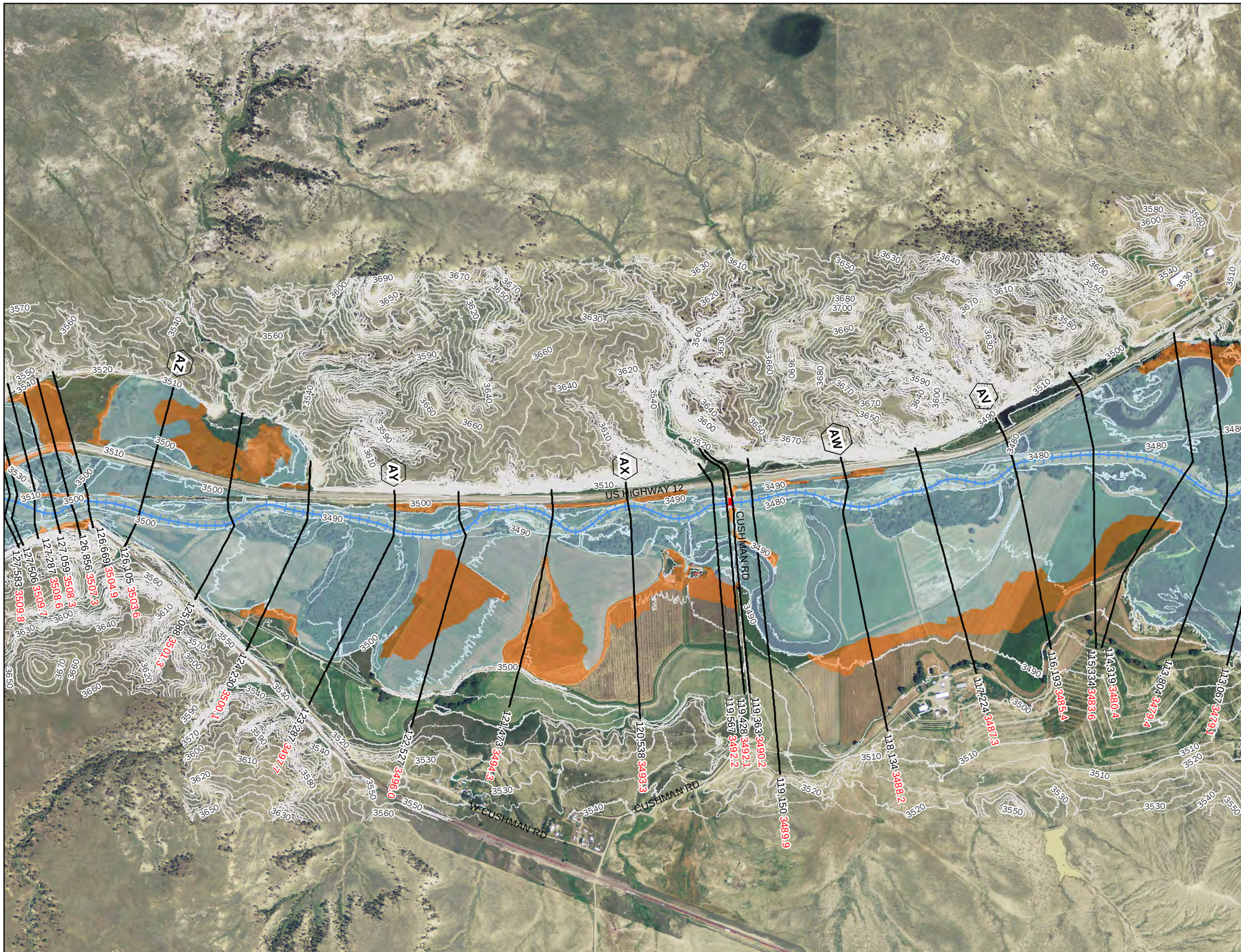


Musselshell River Map 5 of 14



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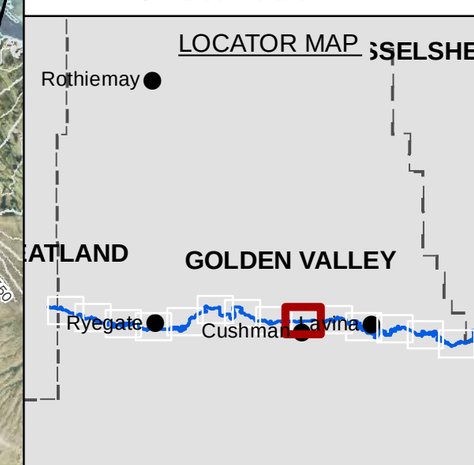
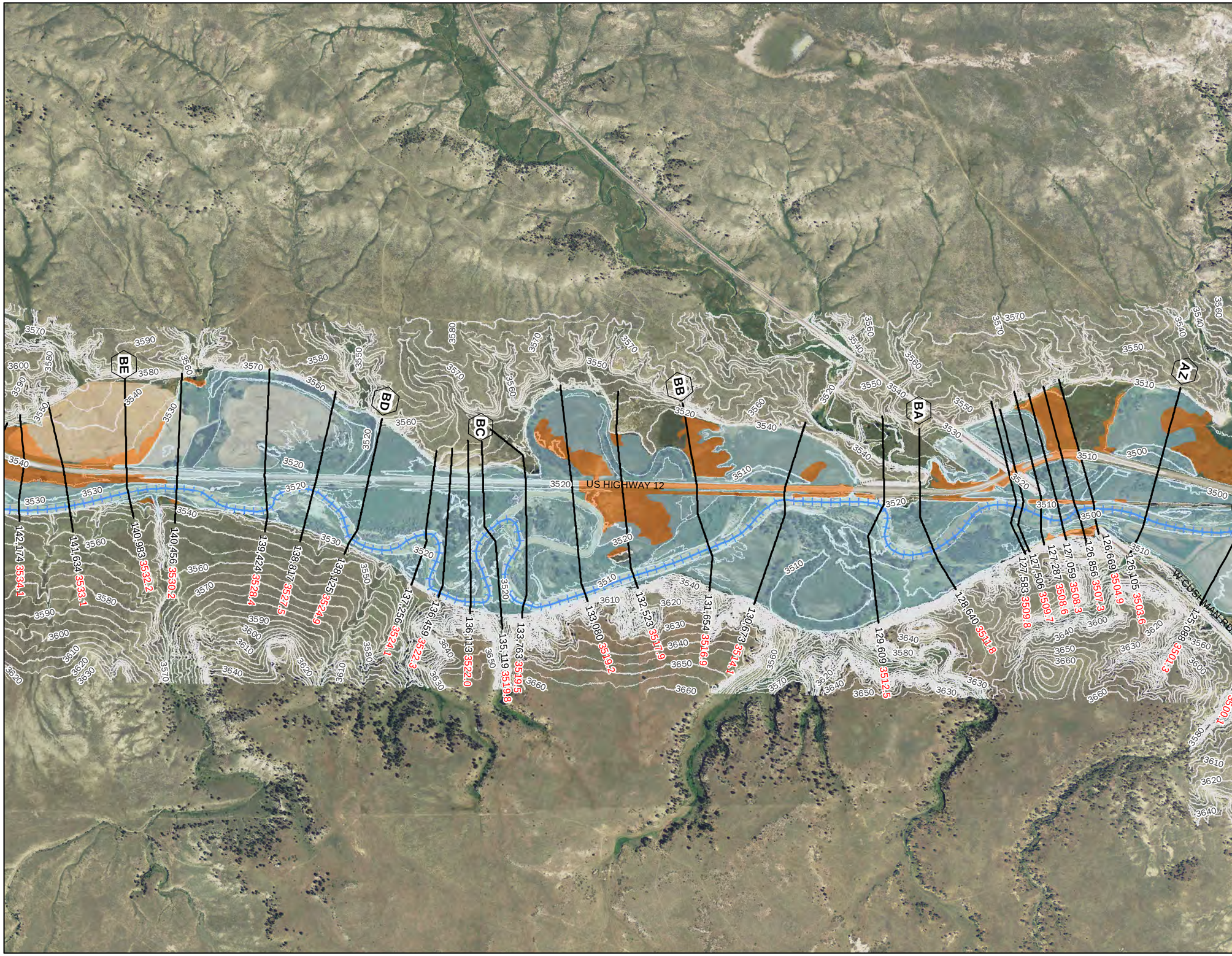


Musselshell River Map 6 of 14



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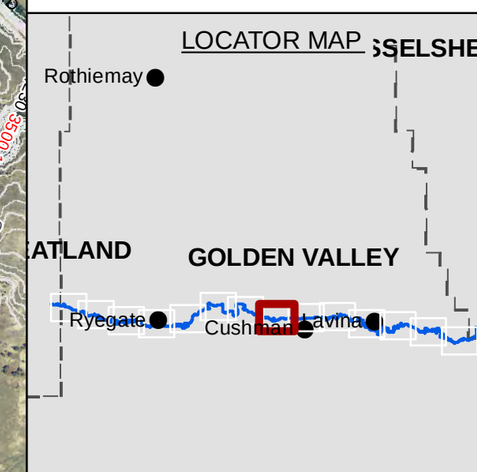
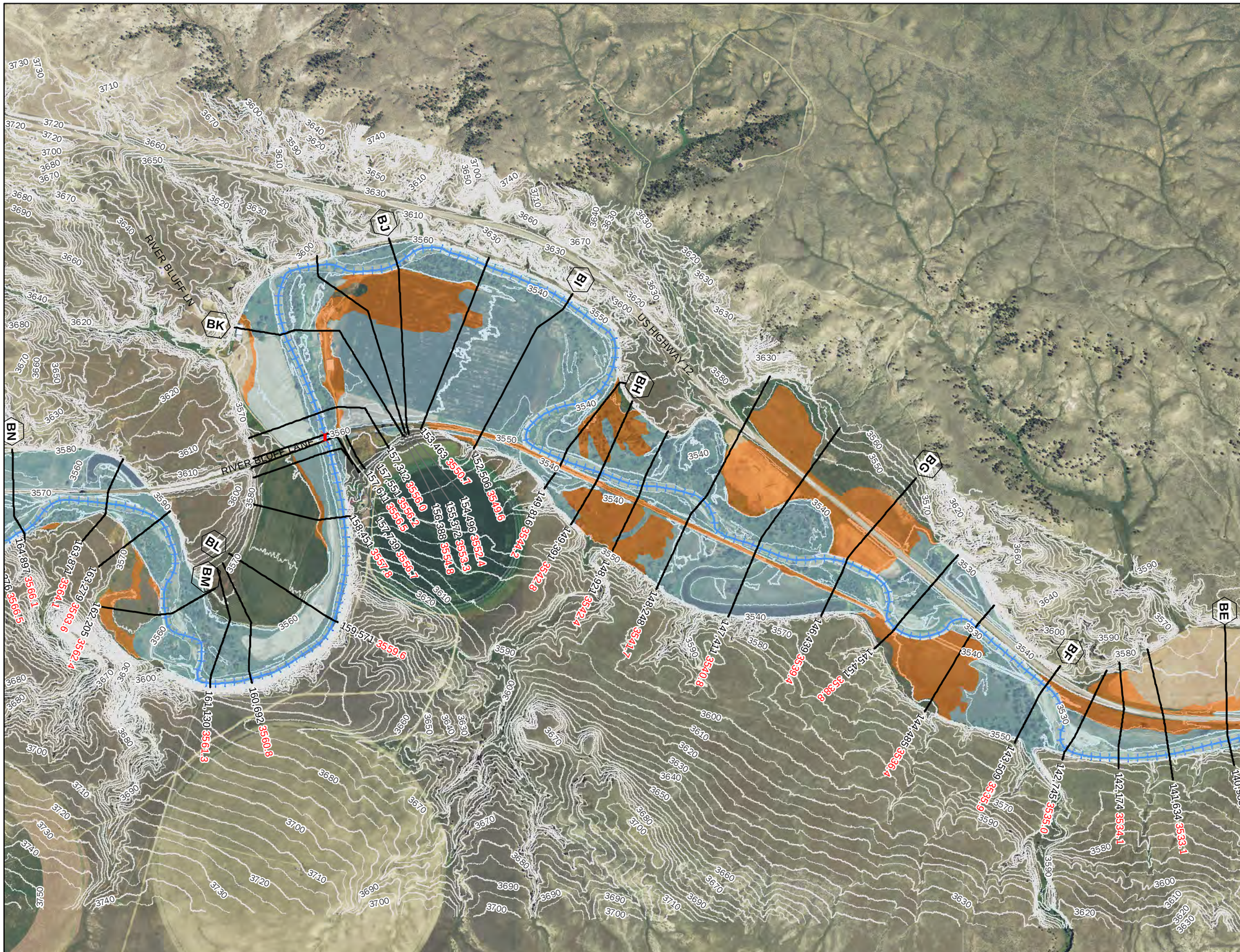


Musselshell River Map 7 of 14



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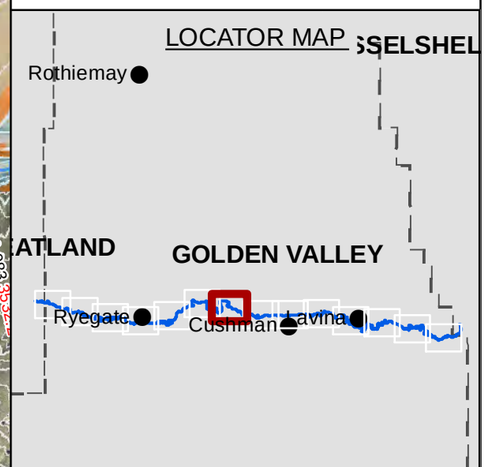
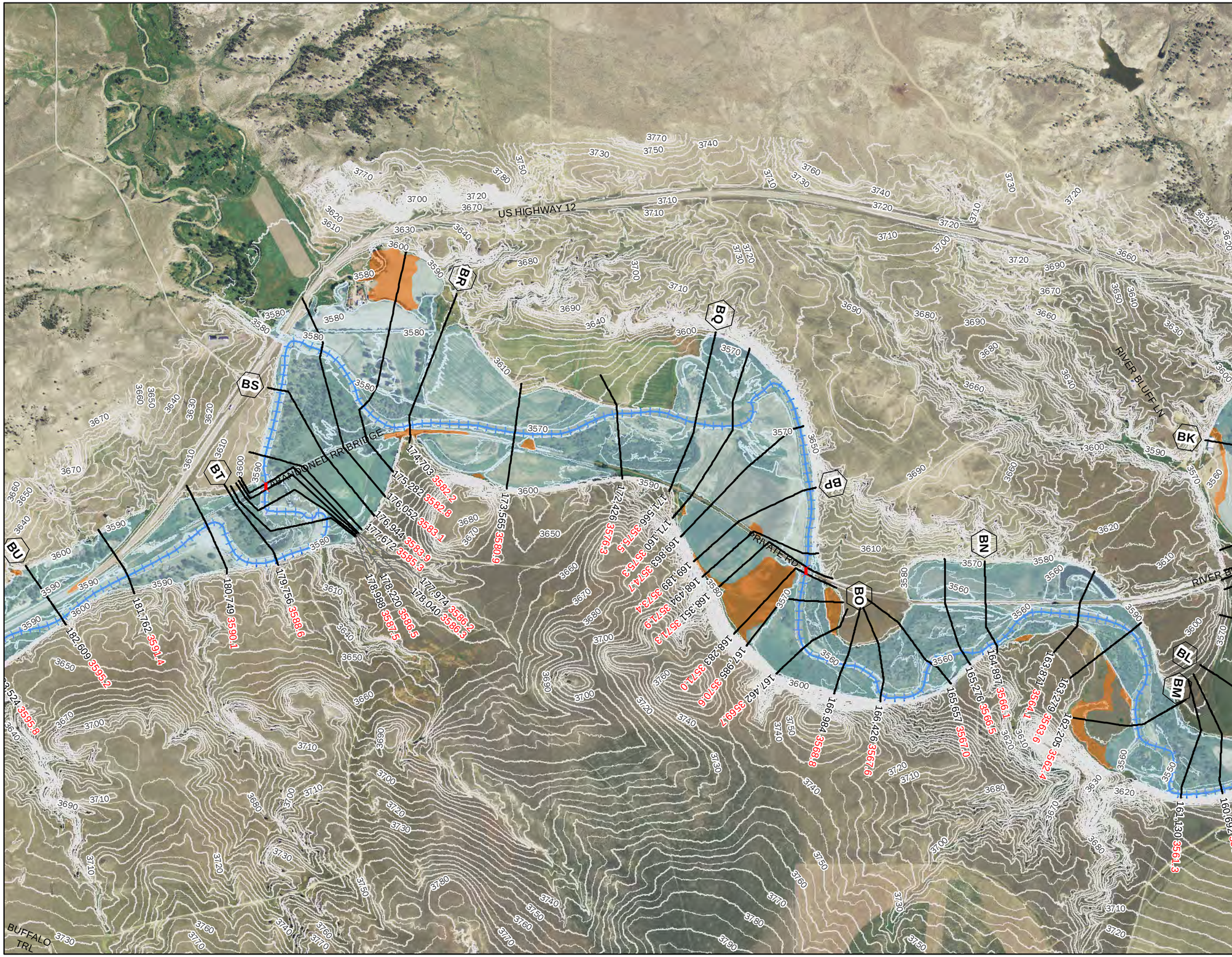


Musselshell River Map 8 of 14

GOLDEN VALLEY COUNTY TOPOGRAPHIC WORKMAP



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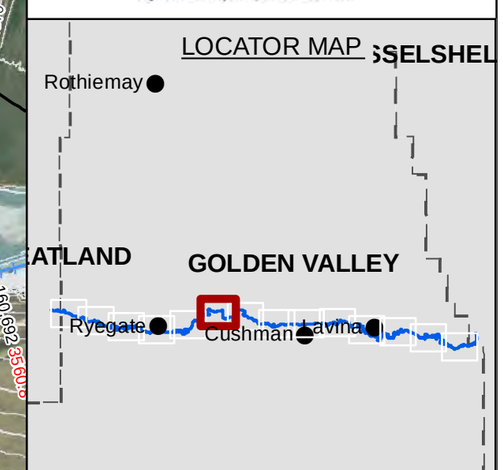
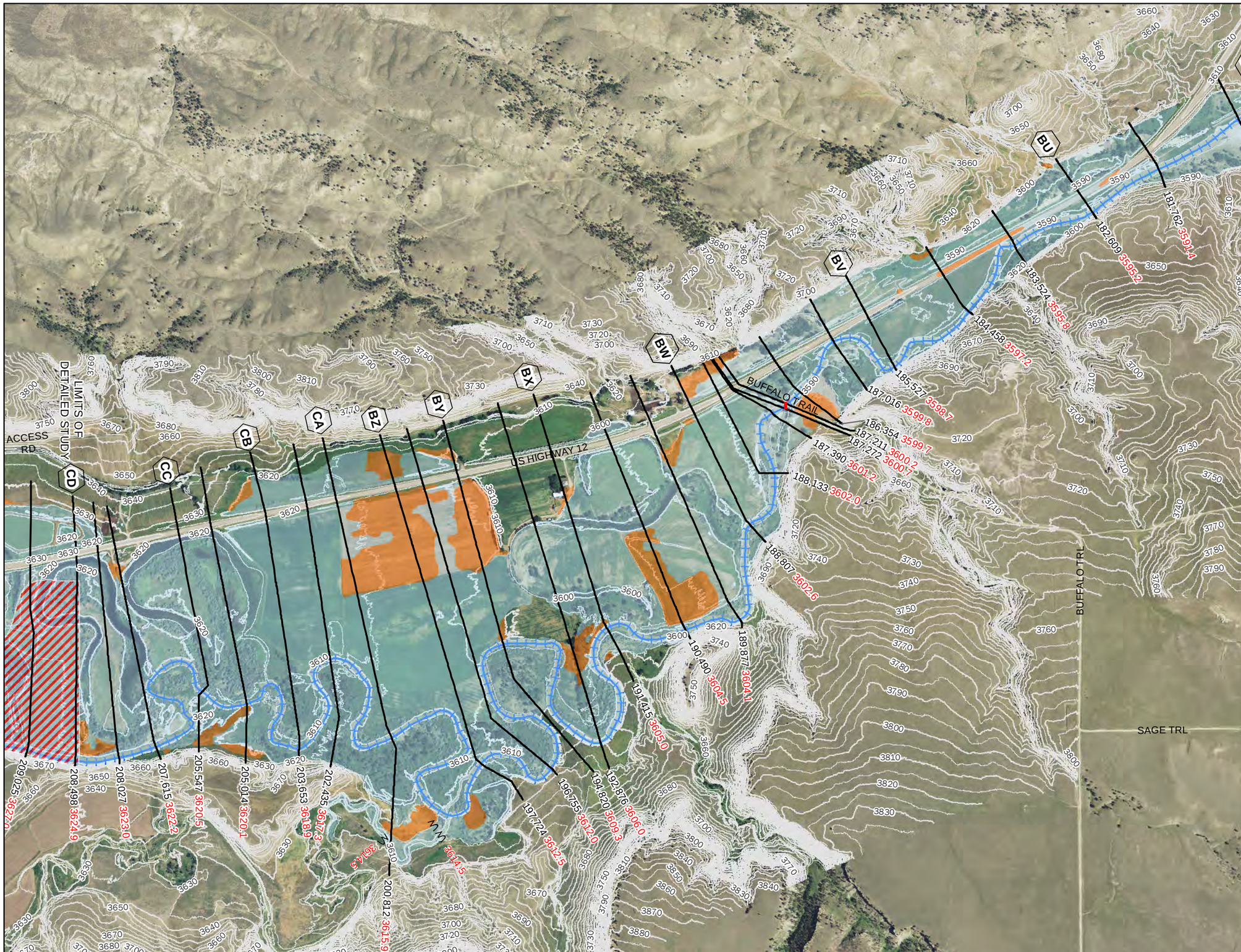


Musselshell River Map 9 of 14

GOLDEN VALLEY COUNTY TOPOGRAPHIC WORKMAP



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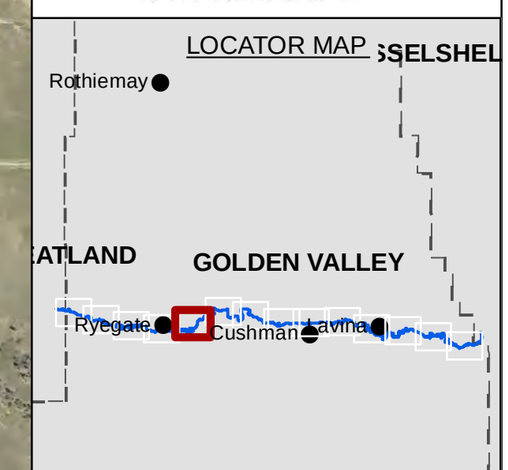
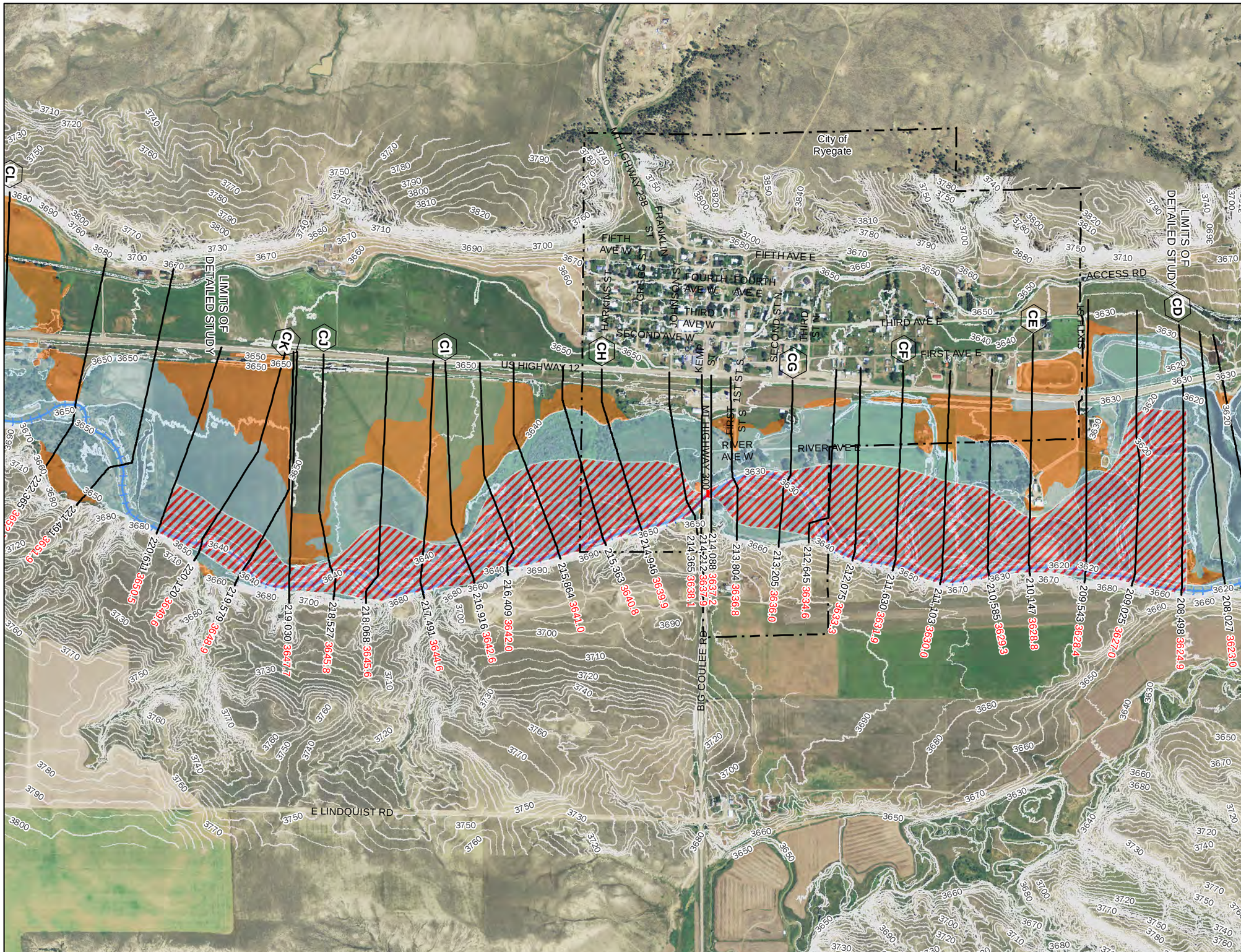


Musselshell River Map 10 of 14

GOLDEN VALLEY COUNTY TOPOGRAPHIC WORKMAP



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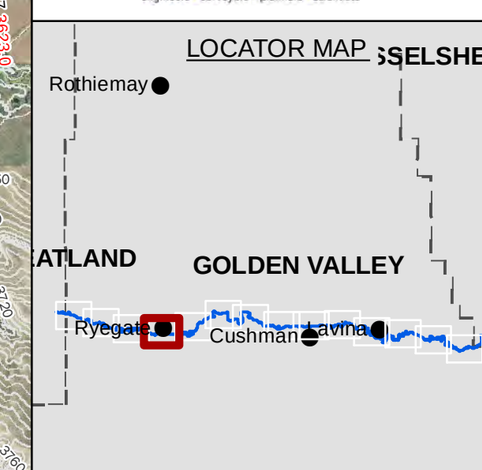

Musselshell River Map 11 of 14

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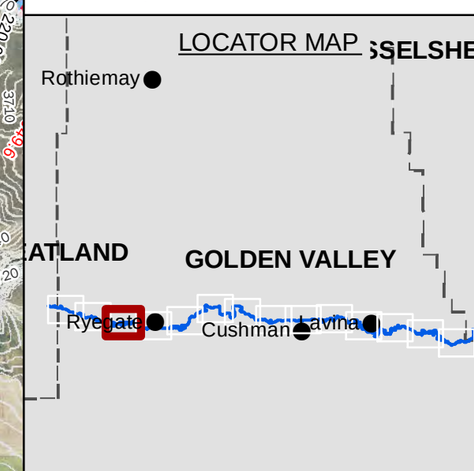
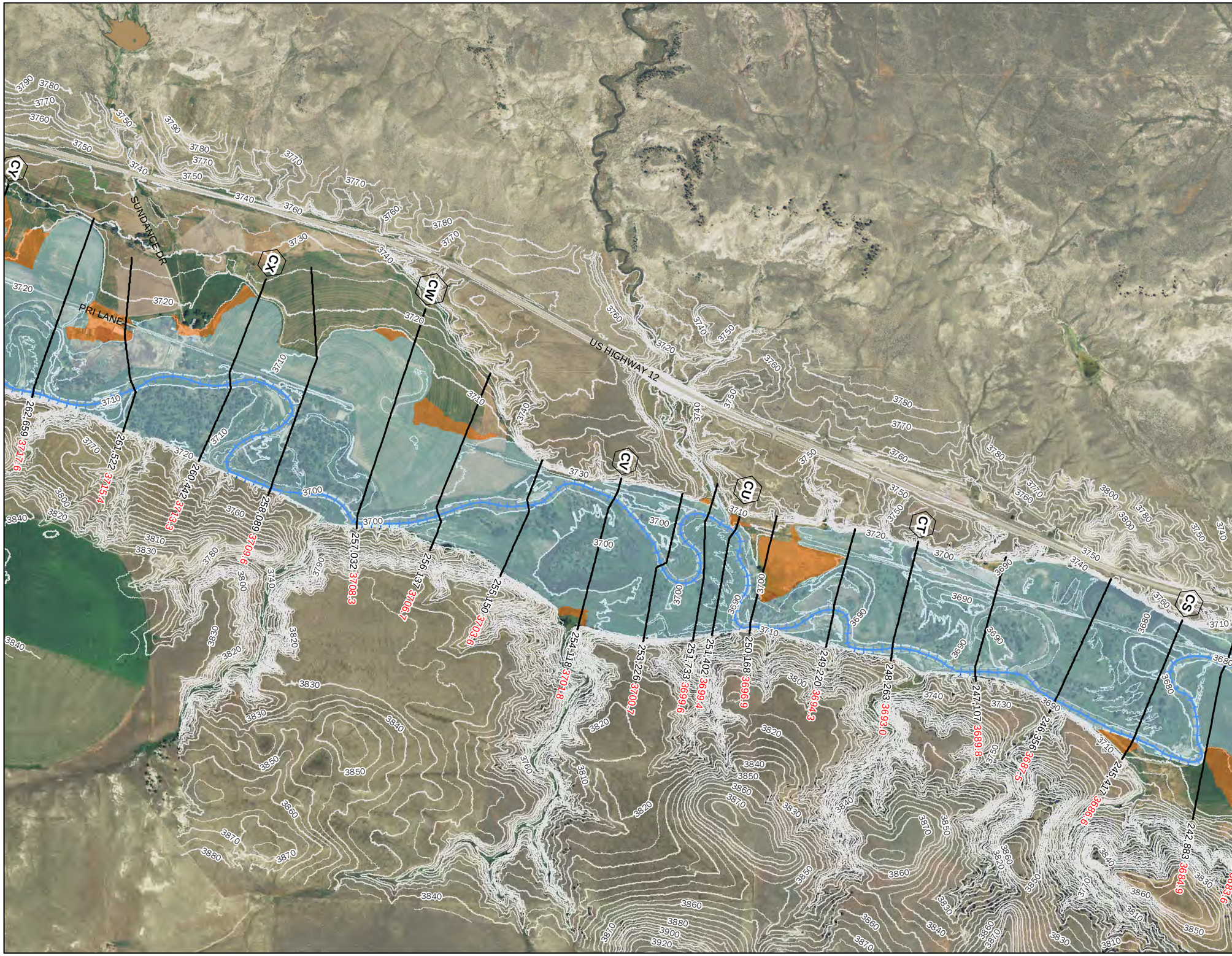


Musselshell River Map 12 of 14



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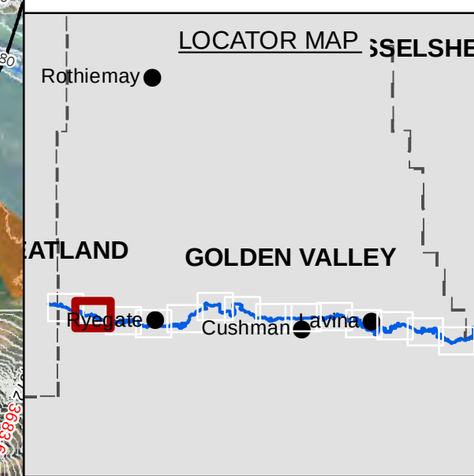
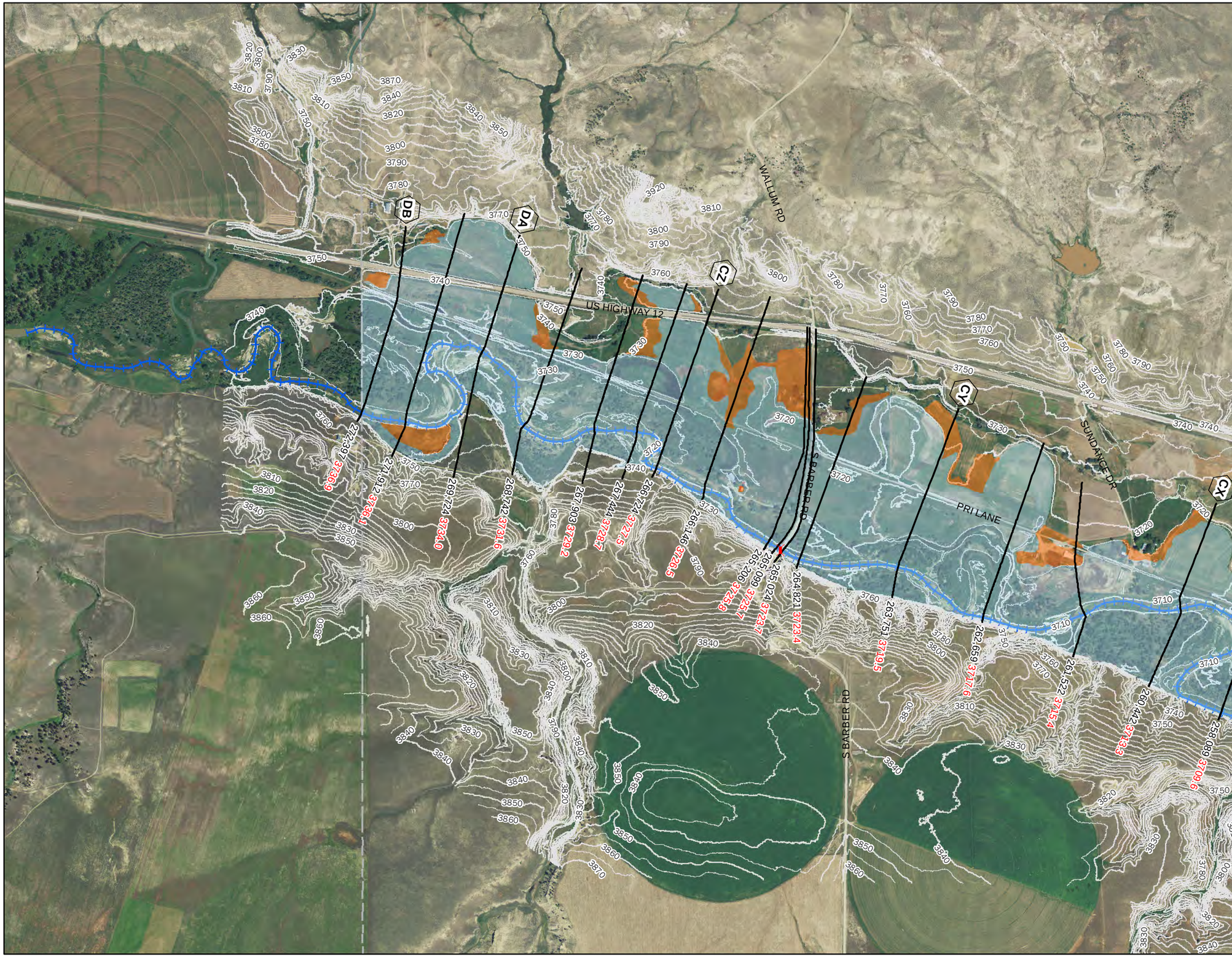


Musselshell River Map 13 of 14



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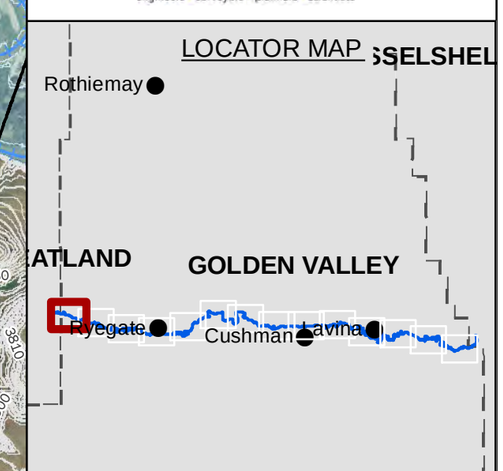
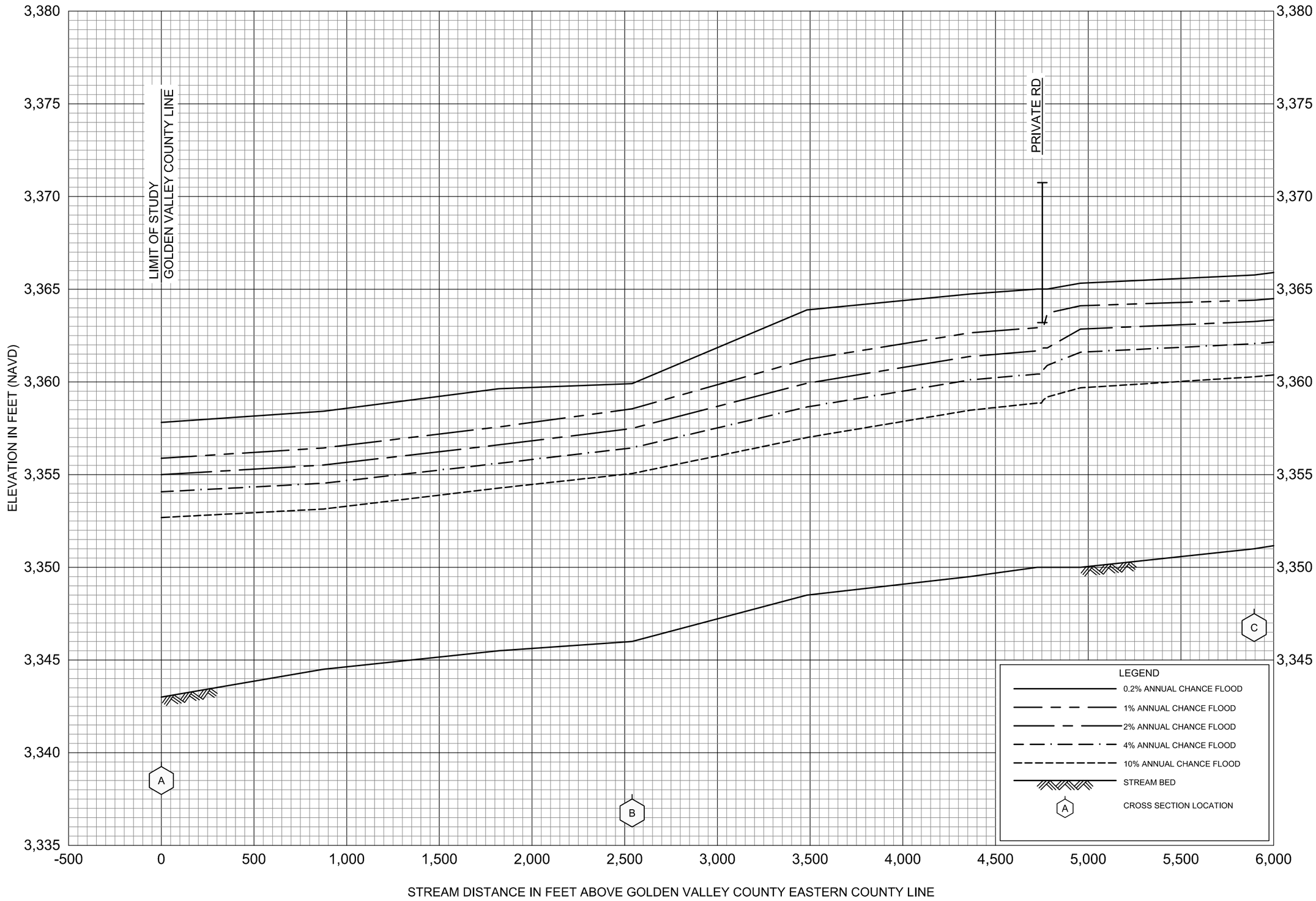


Musselshell River Map 14 of 14

Appendix B – Profiles

- Reach 2
- Reach 7
- Reach 8



FLOOD PROFILES

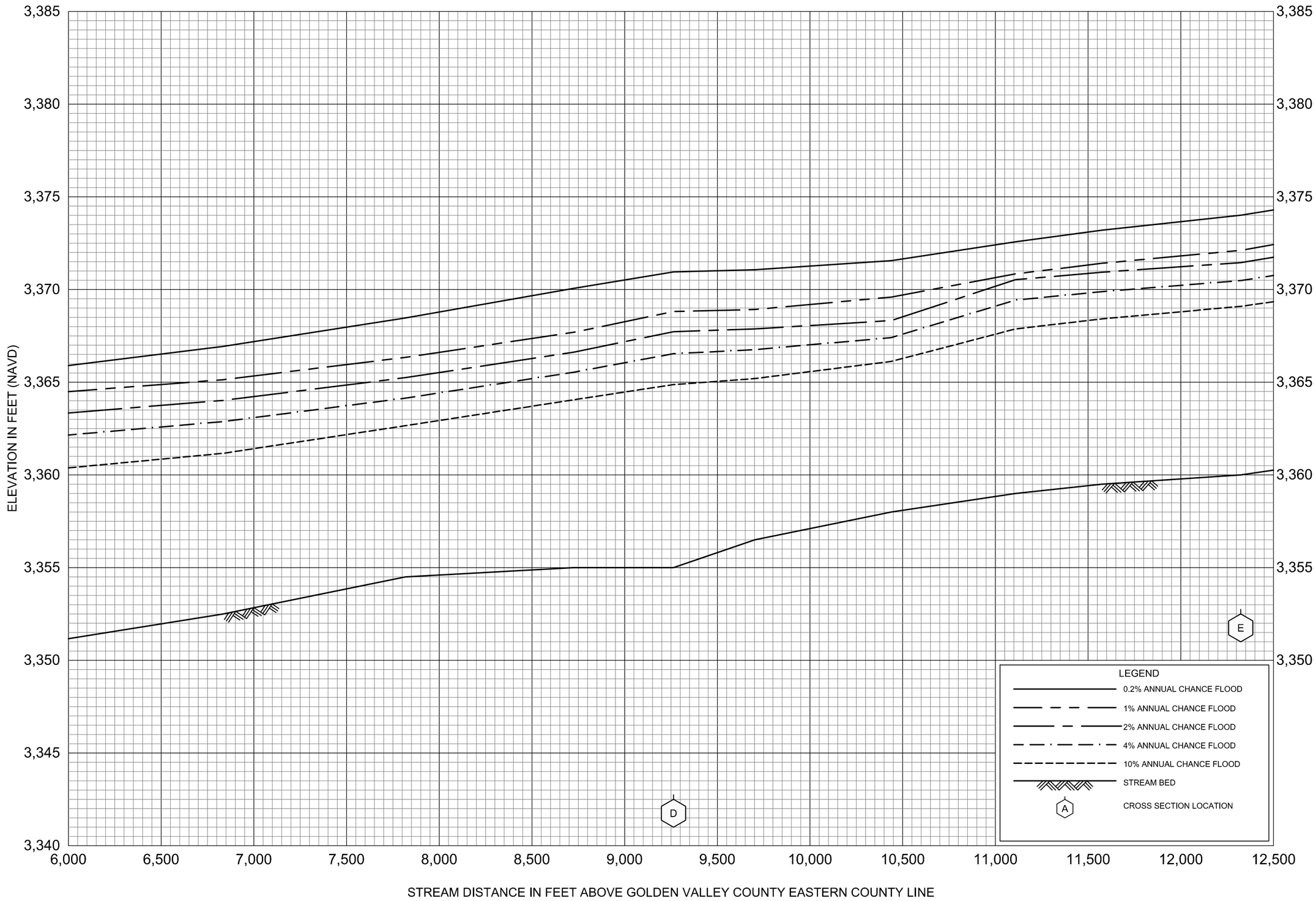
MUSSELSHELL RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GOLDEN VALLEY COUNTY, MT

AND INCORPORATED AREAS

01P



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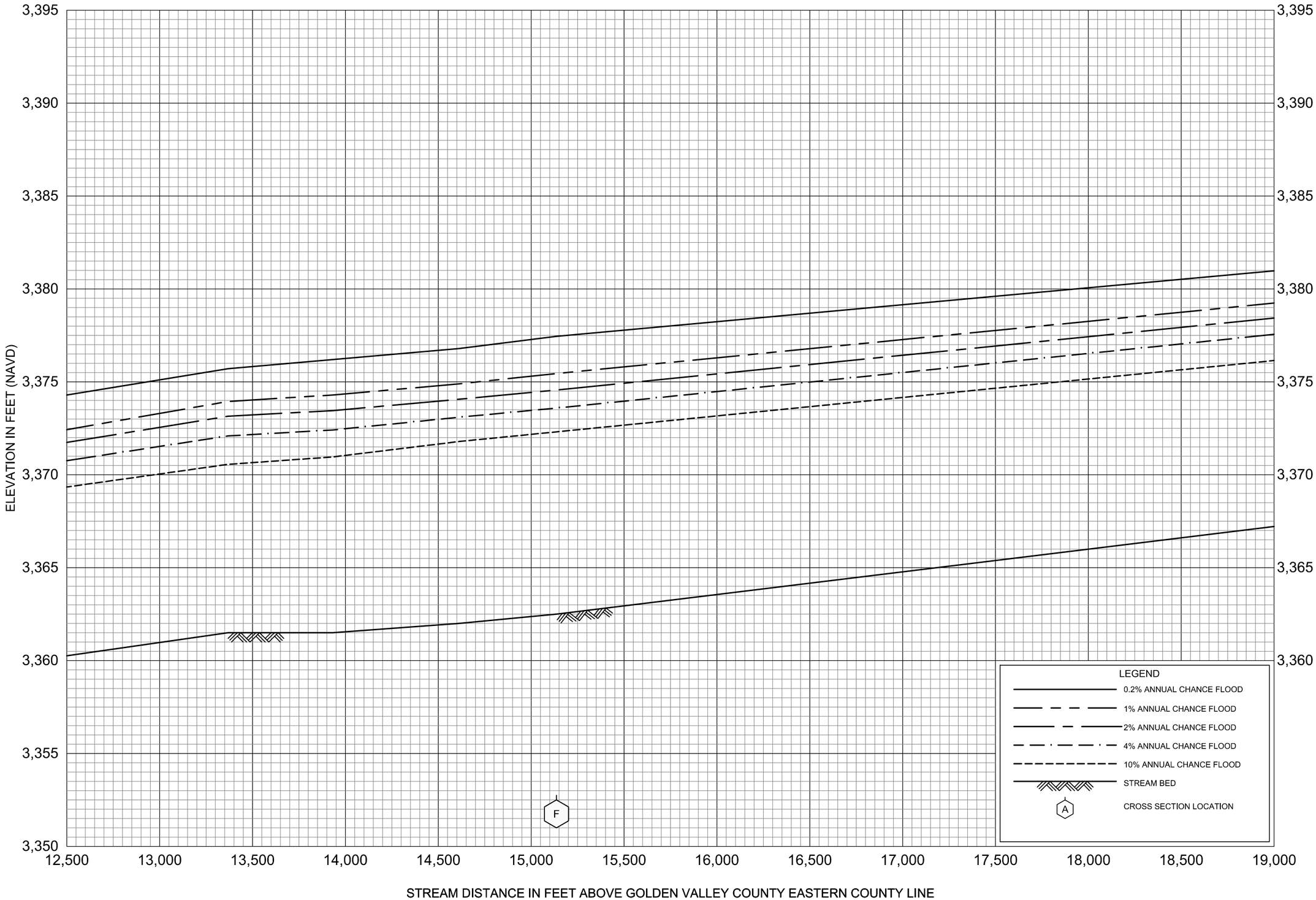

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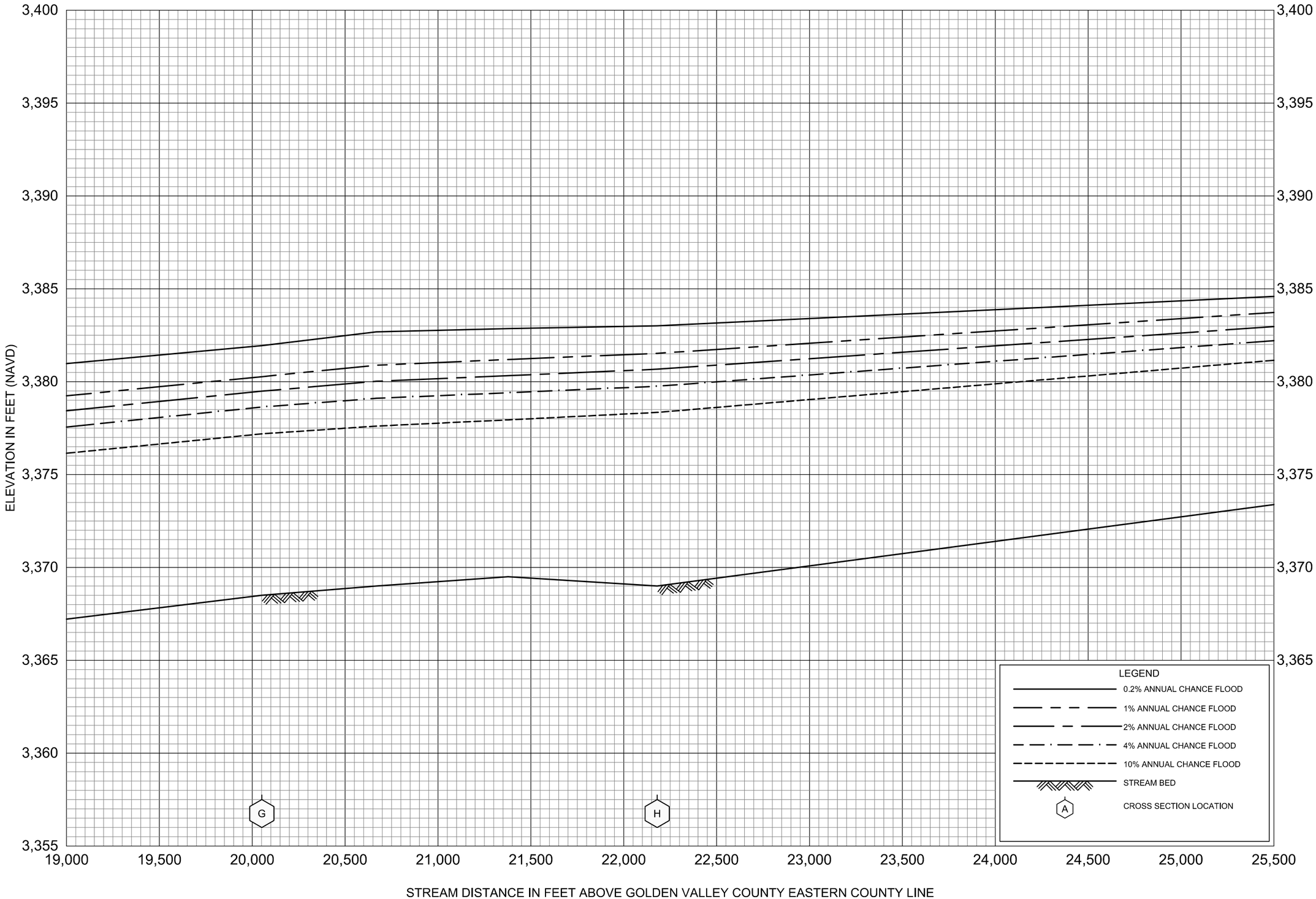

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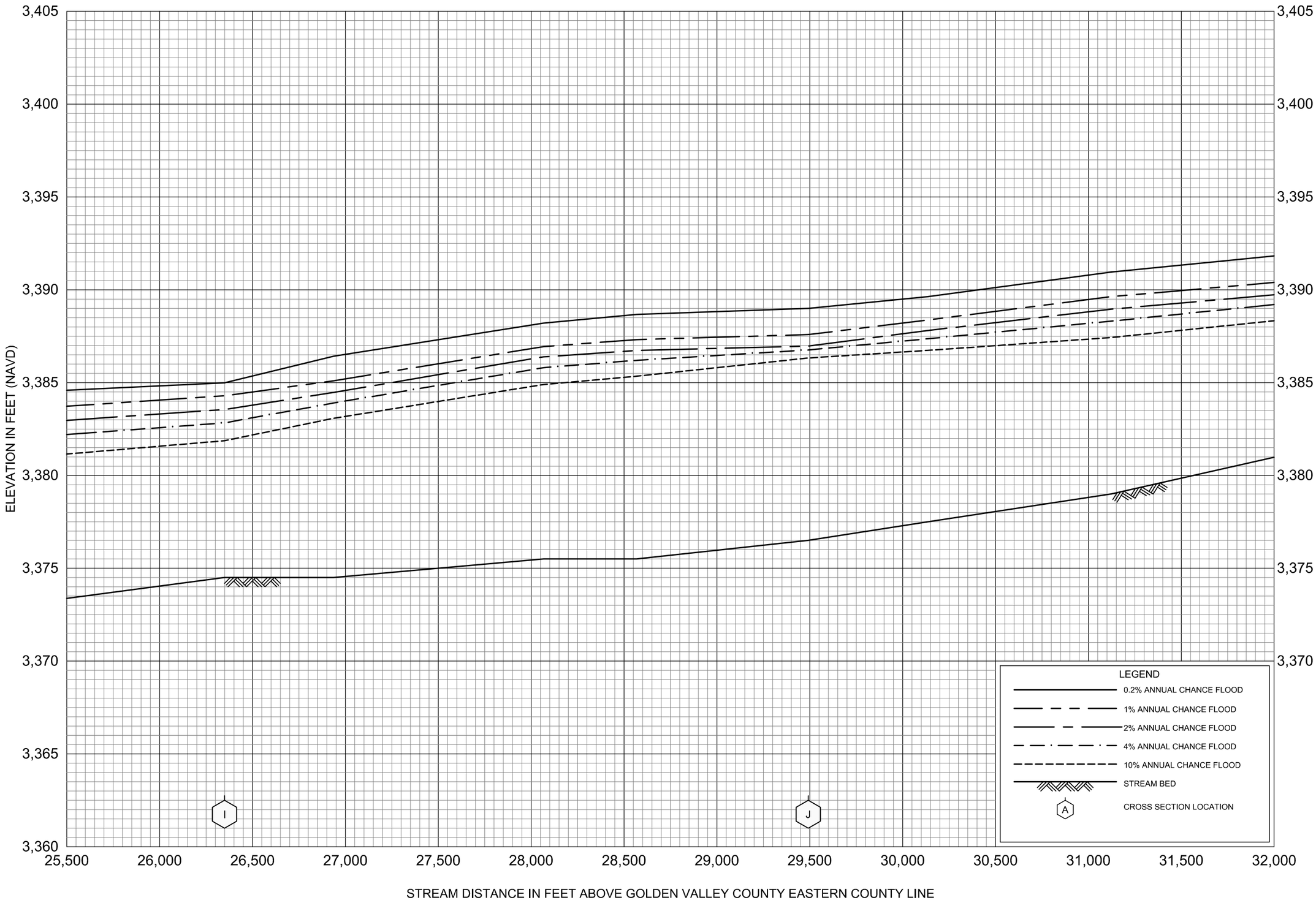

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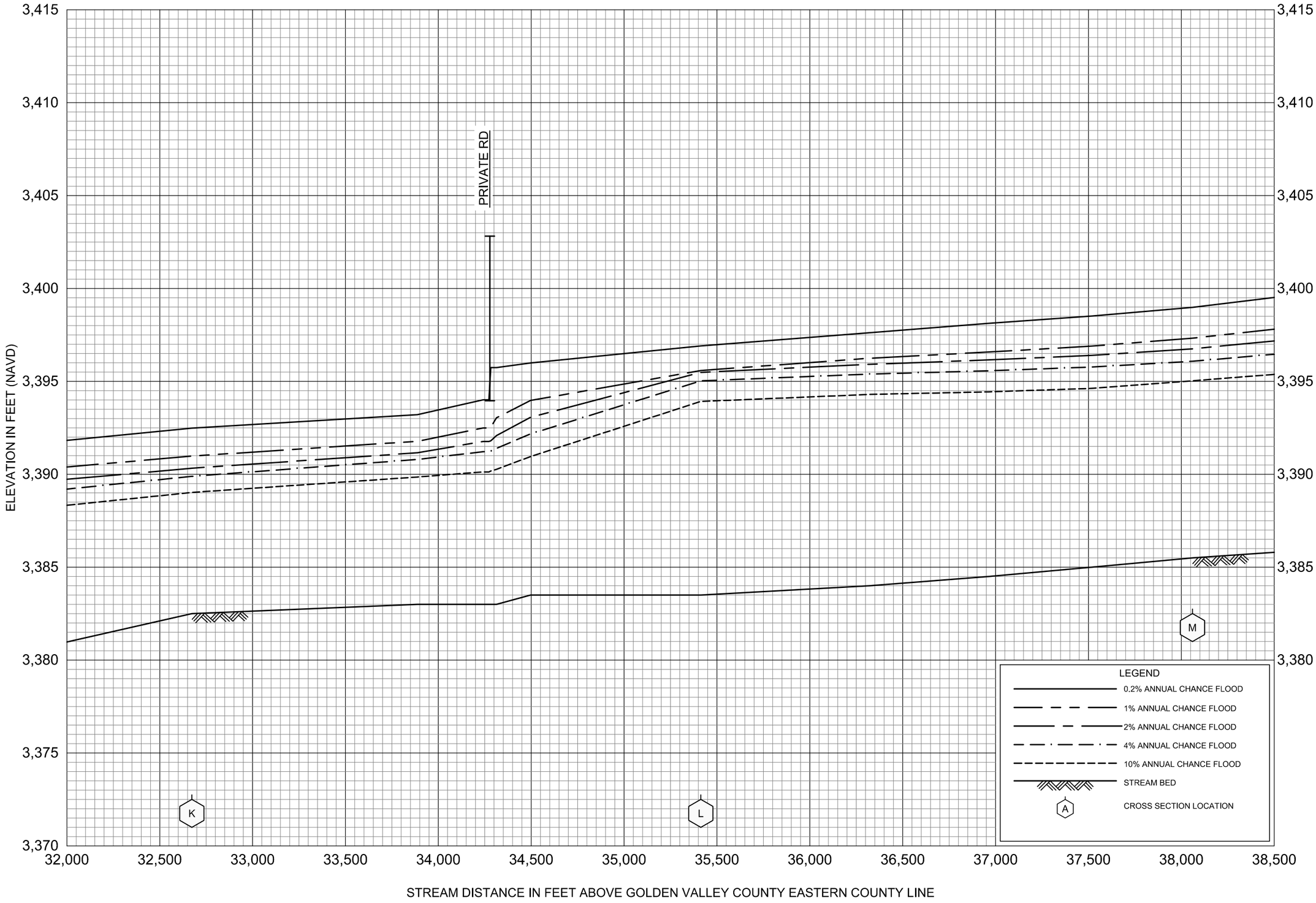

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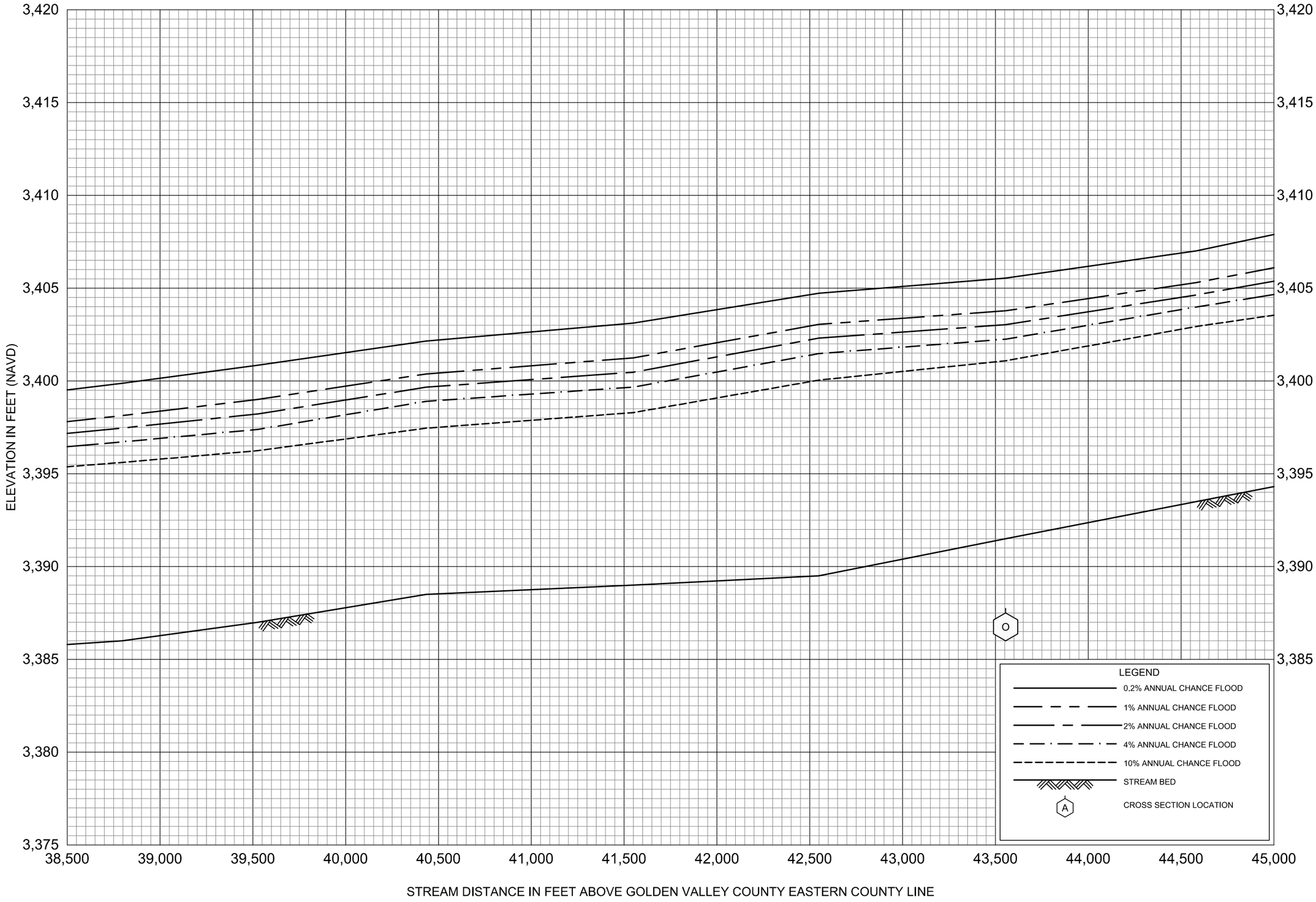

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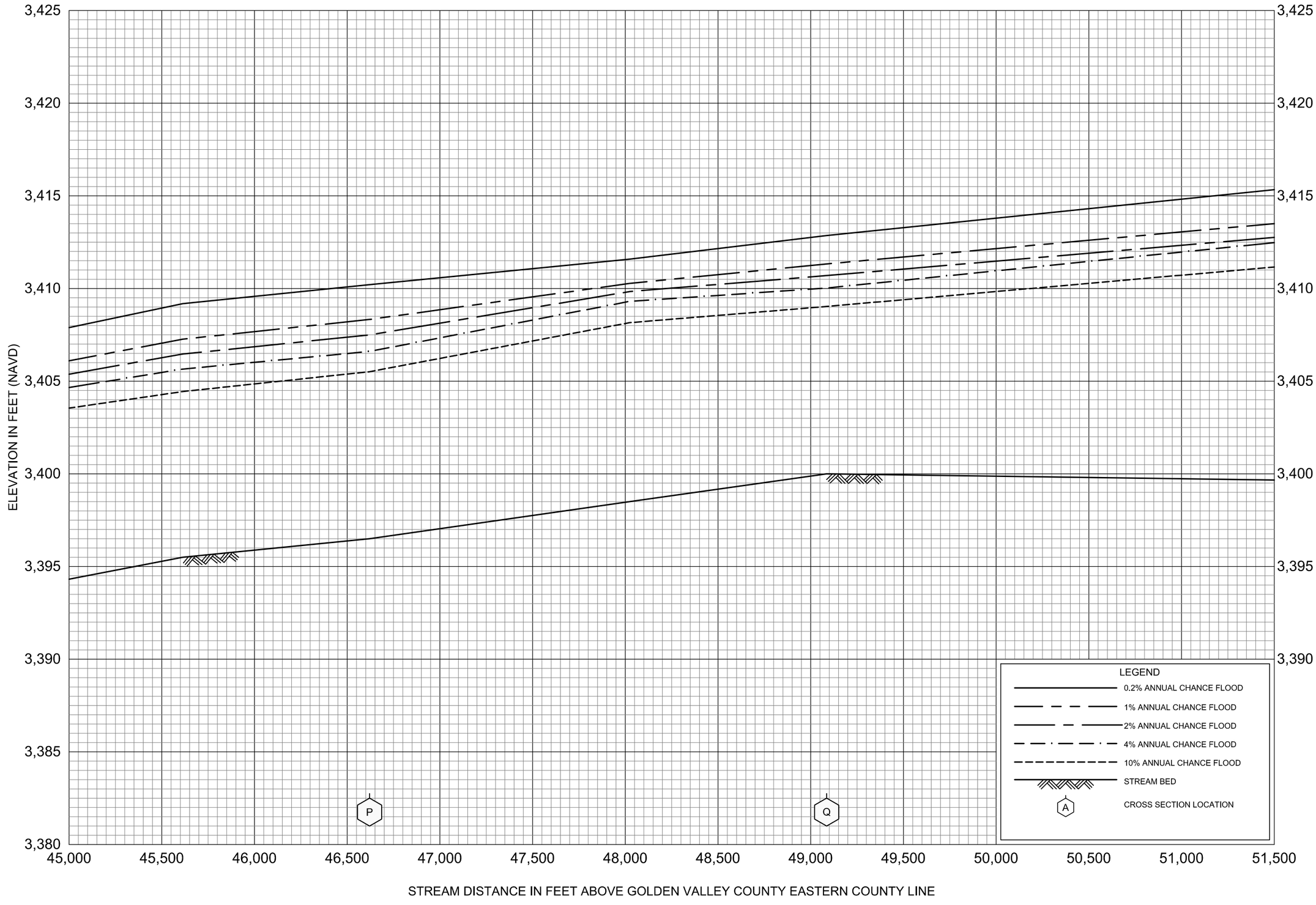

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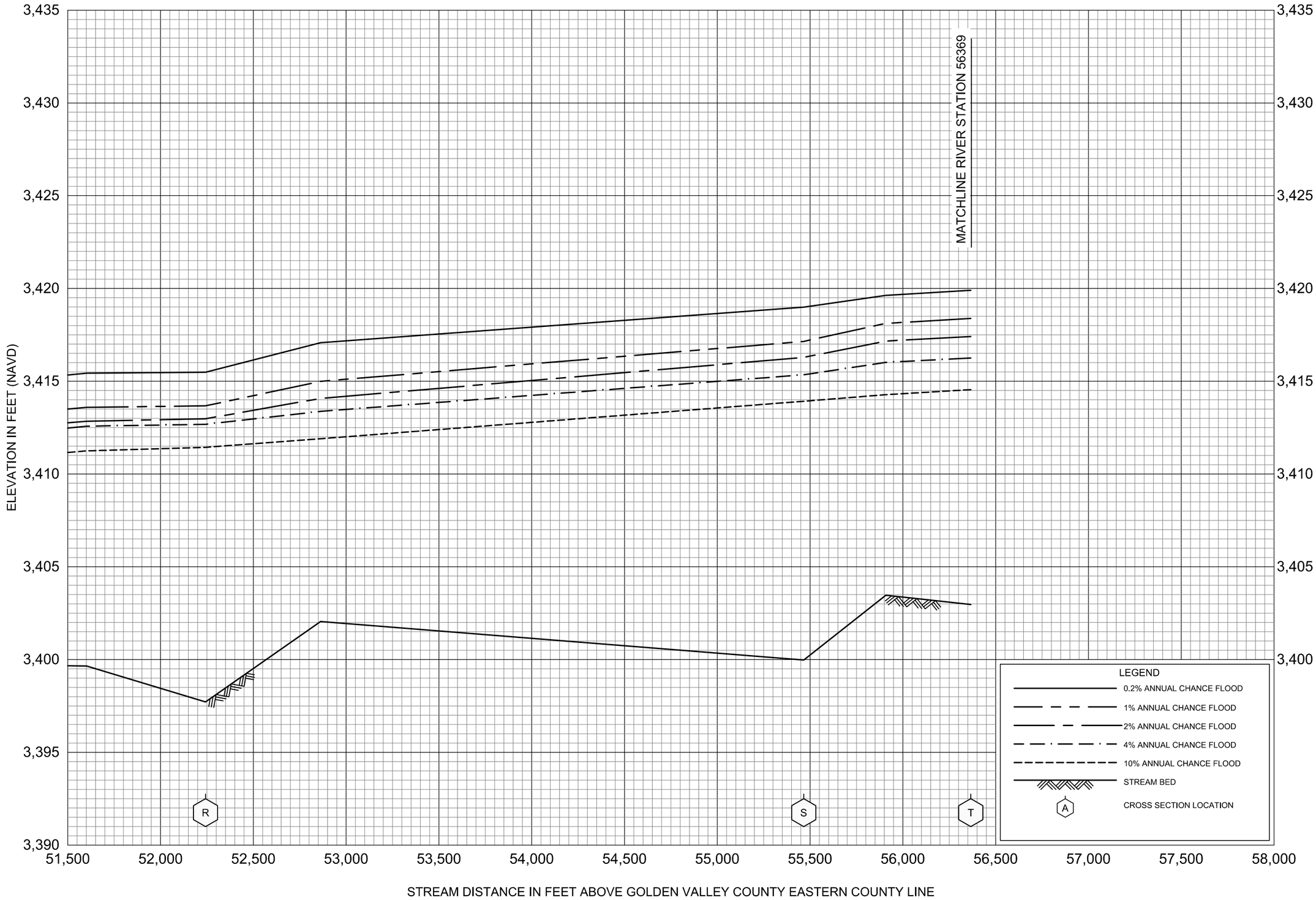

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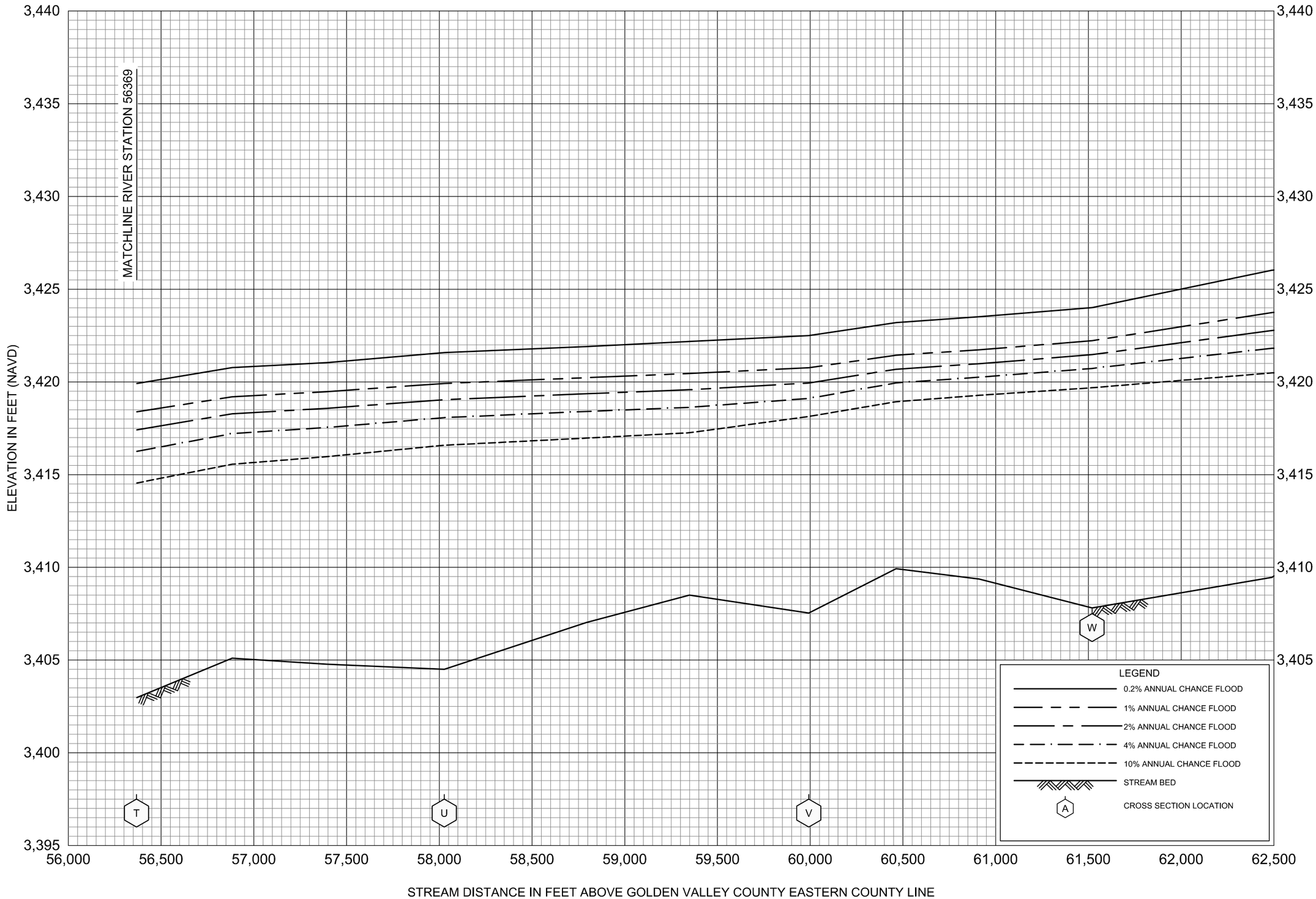

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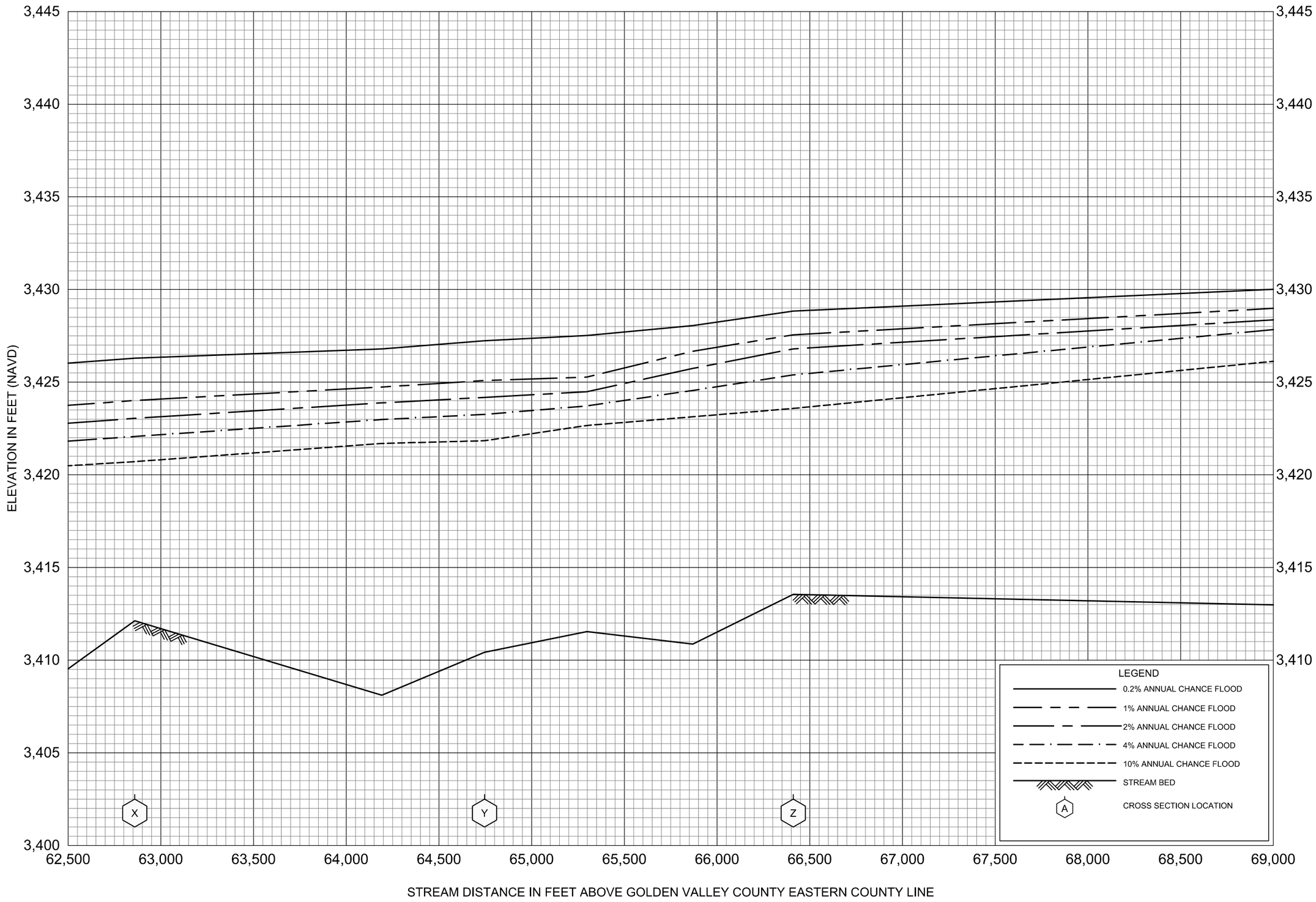

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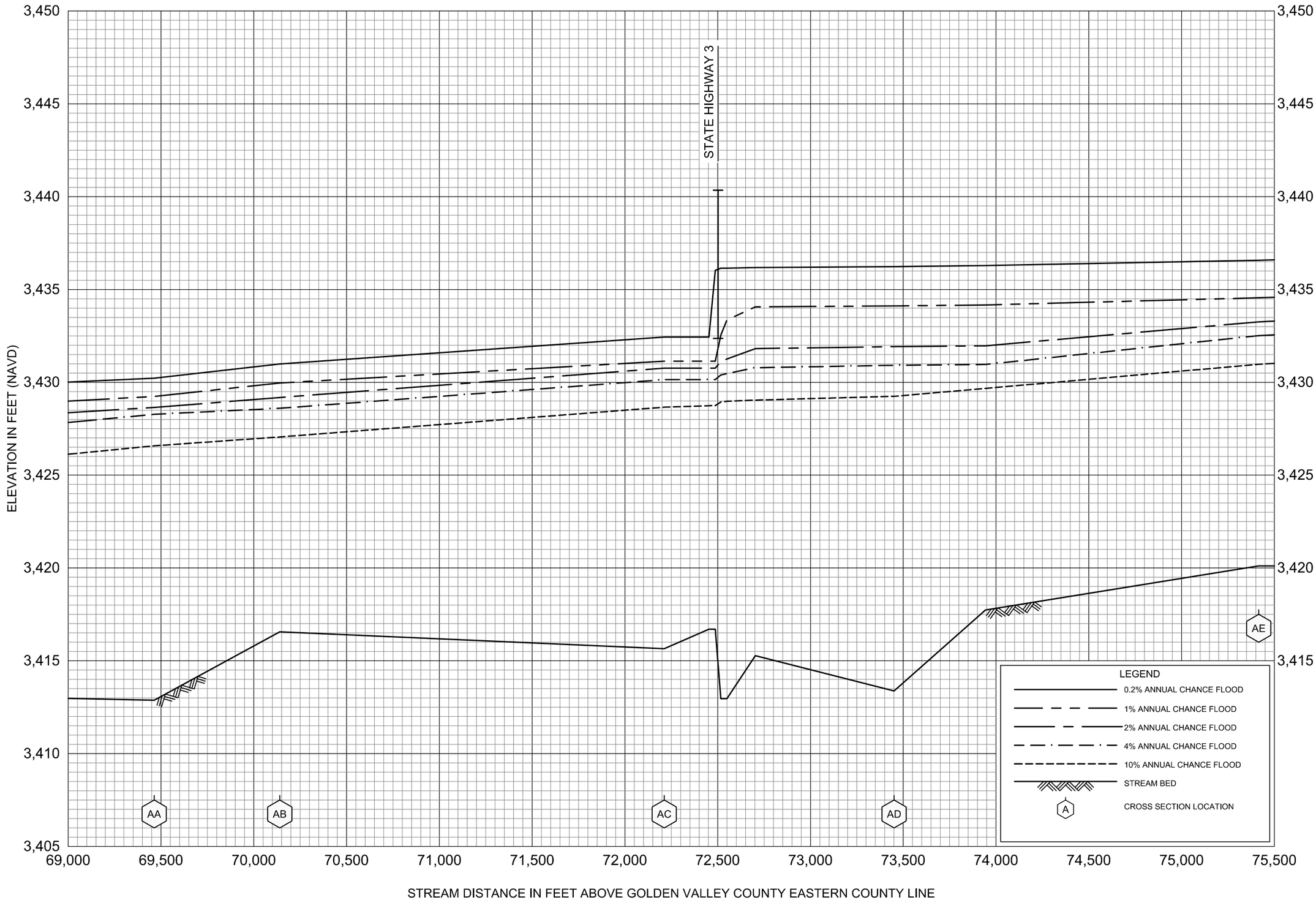

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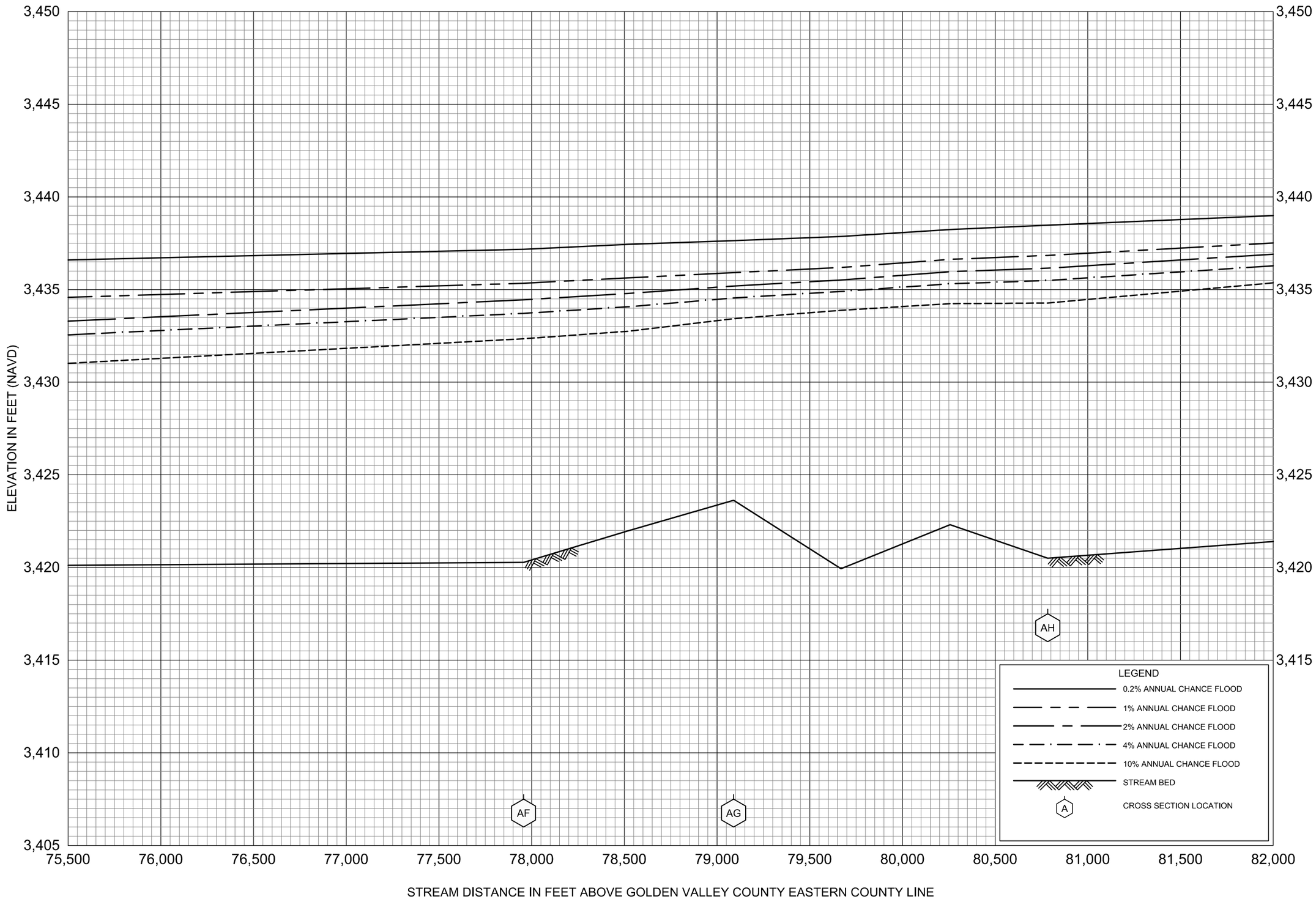

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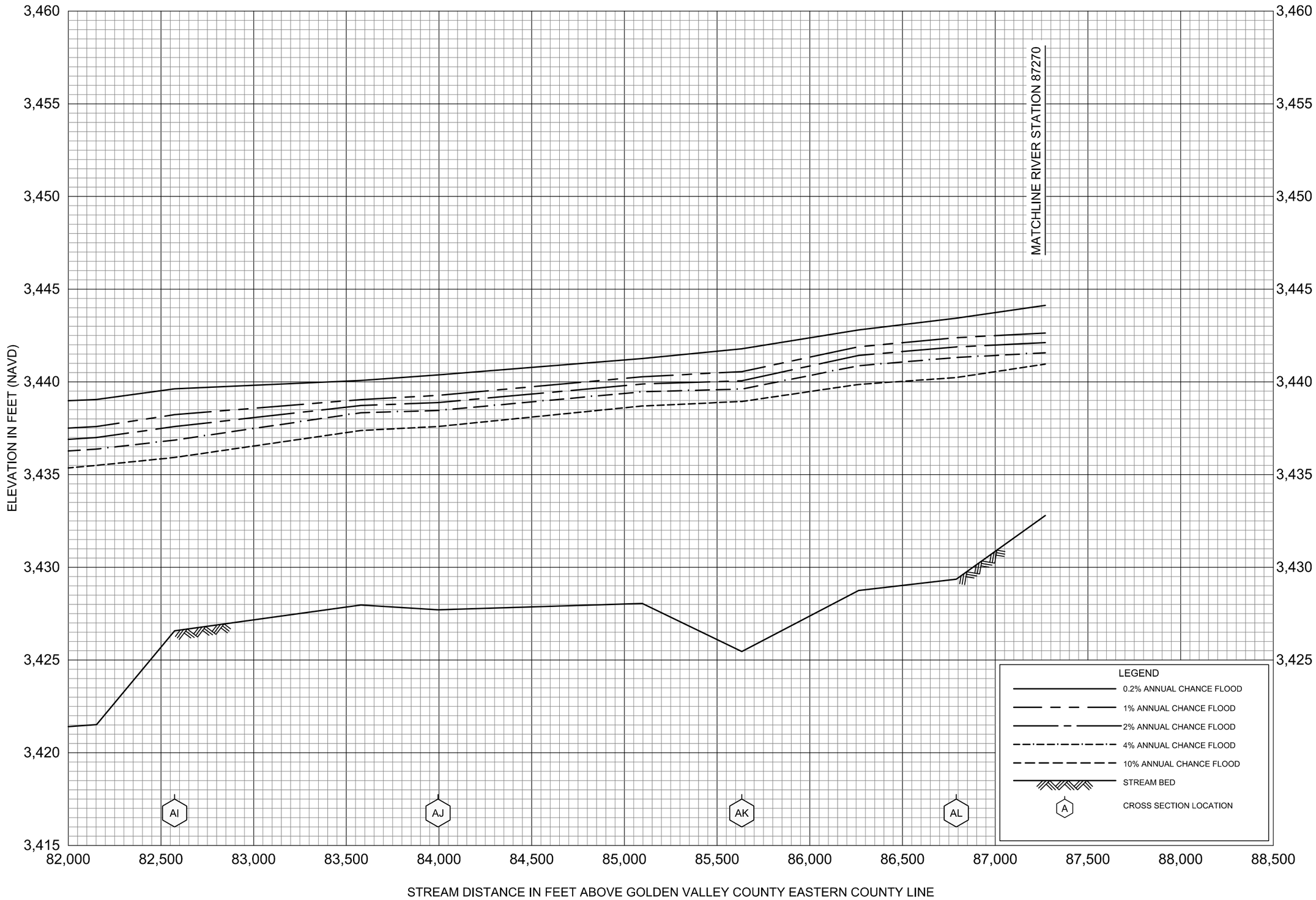

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GOLDEN VALLEY COUNTY, MT

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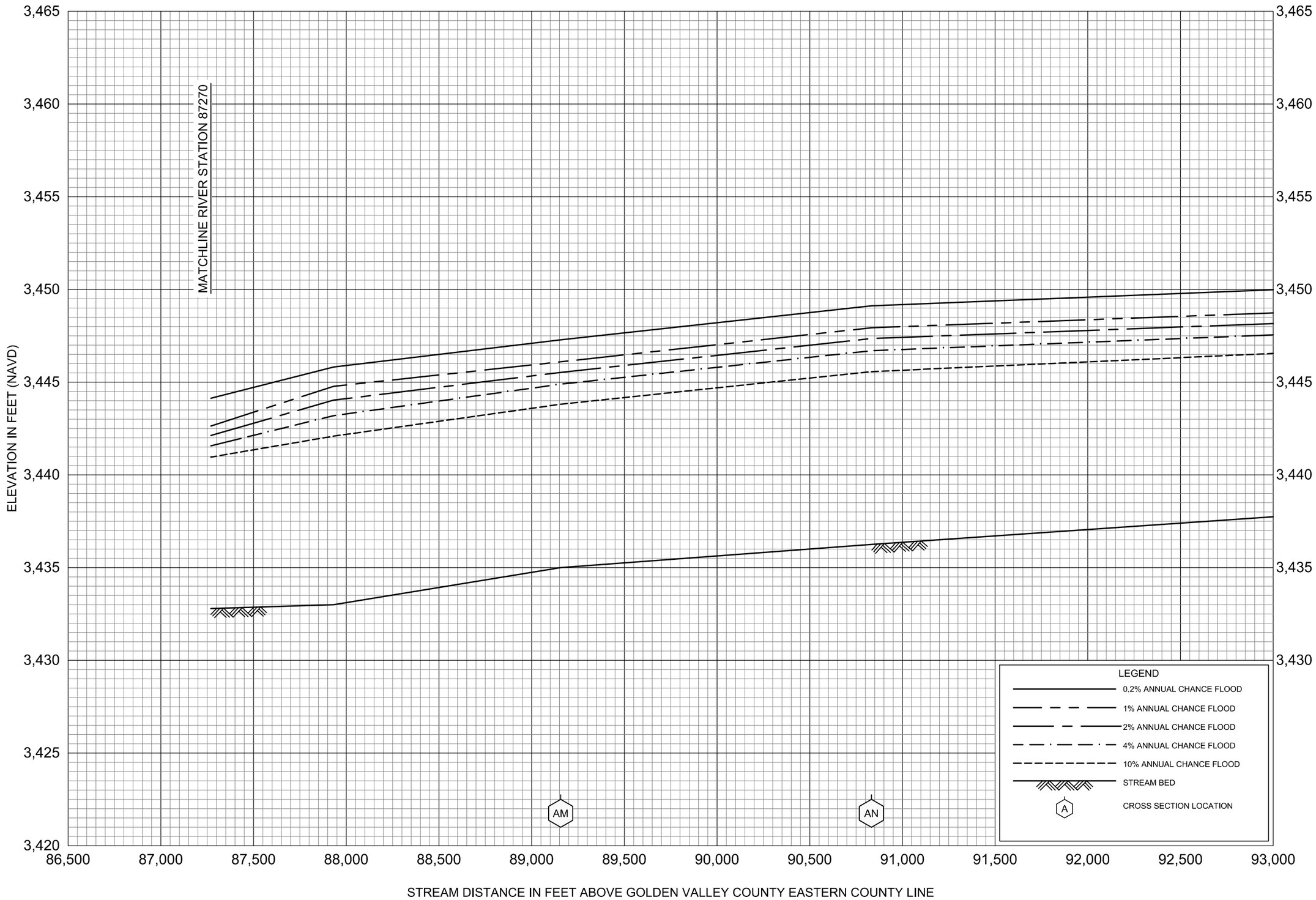


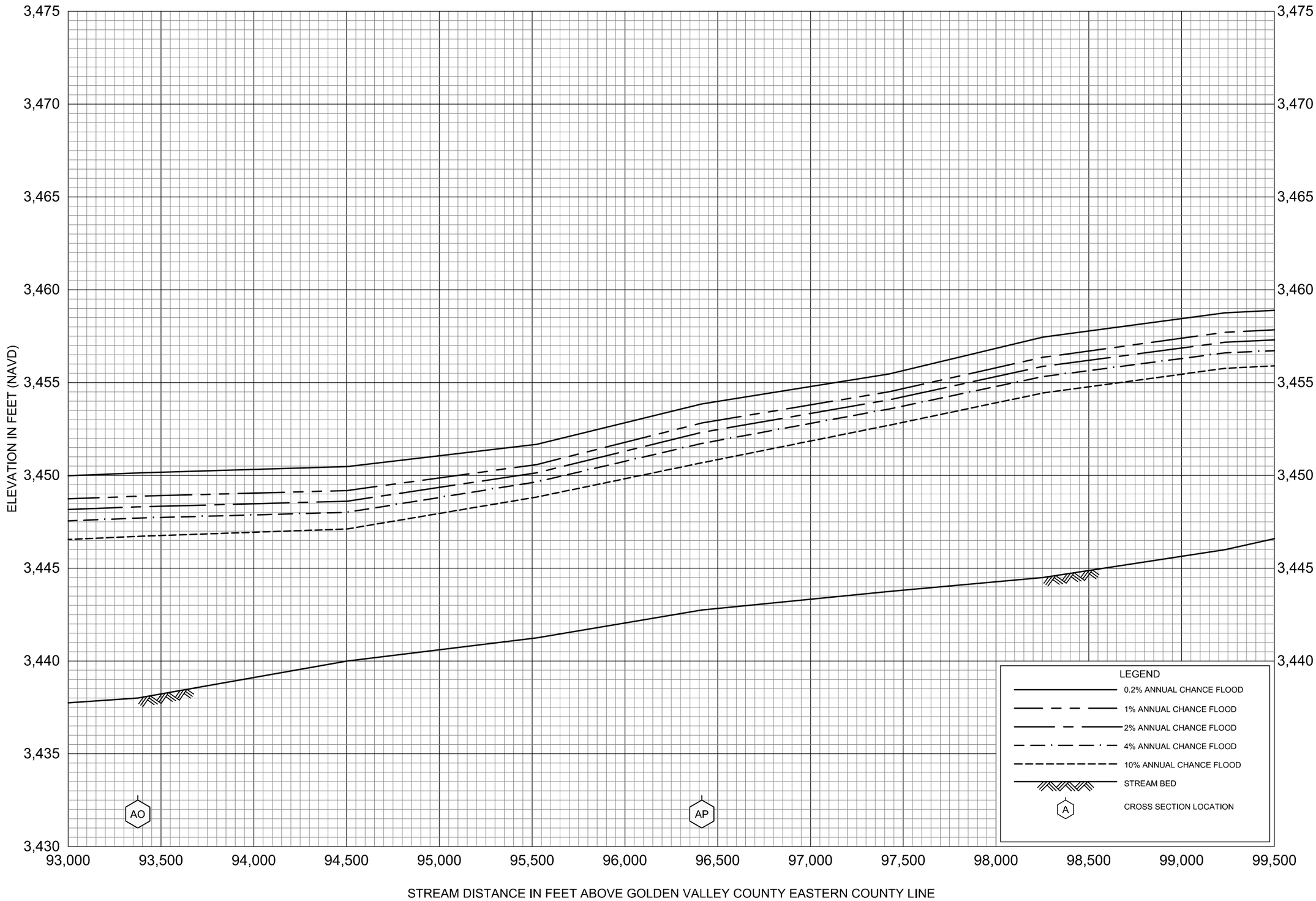
FLOOD PROFILES

MUSSELSHELL RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GOLDEN VALLEY COUNTY, MT

AND INCORPORATED AREAS



FLOOD PROFILES

MUSSELSHELL RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GOLDEN VALLEY COUNTY, MT

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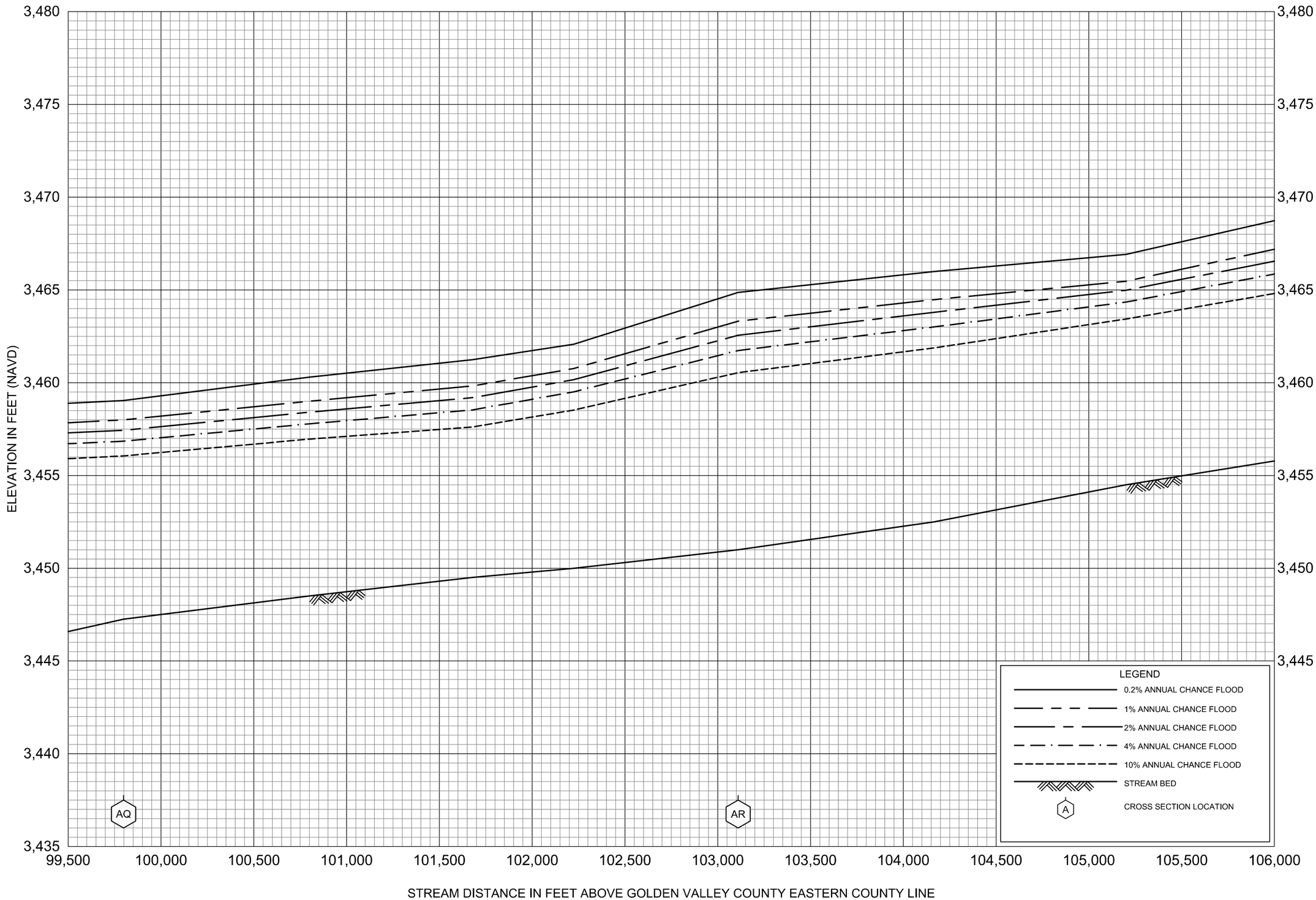

FLOOD PROFILES

MUSSELSHELL RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

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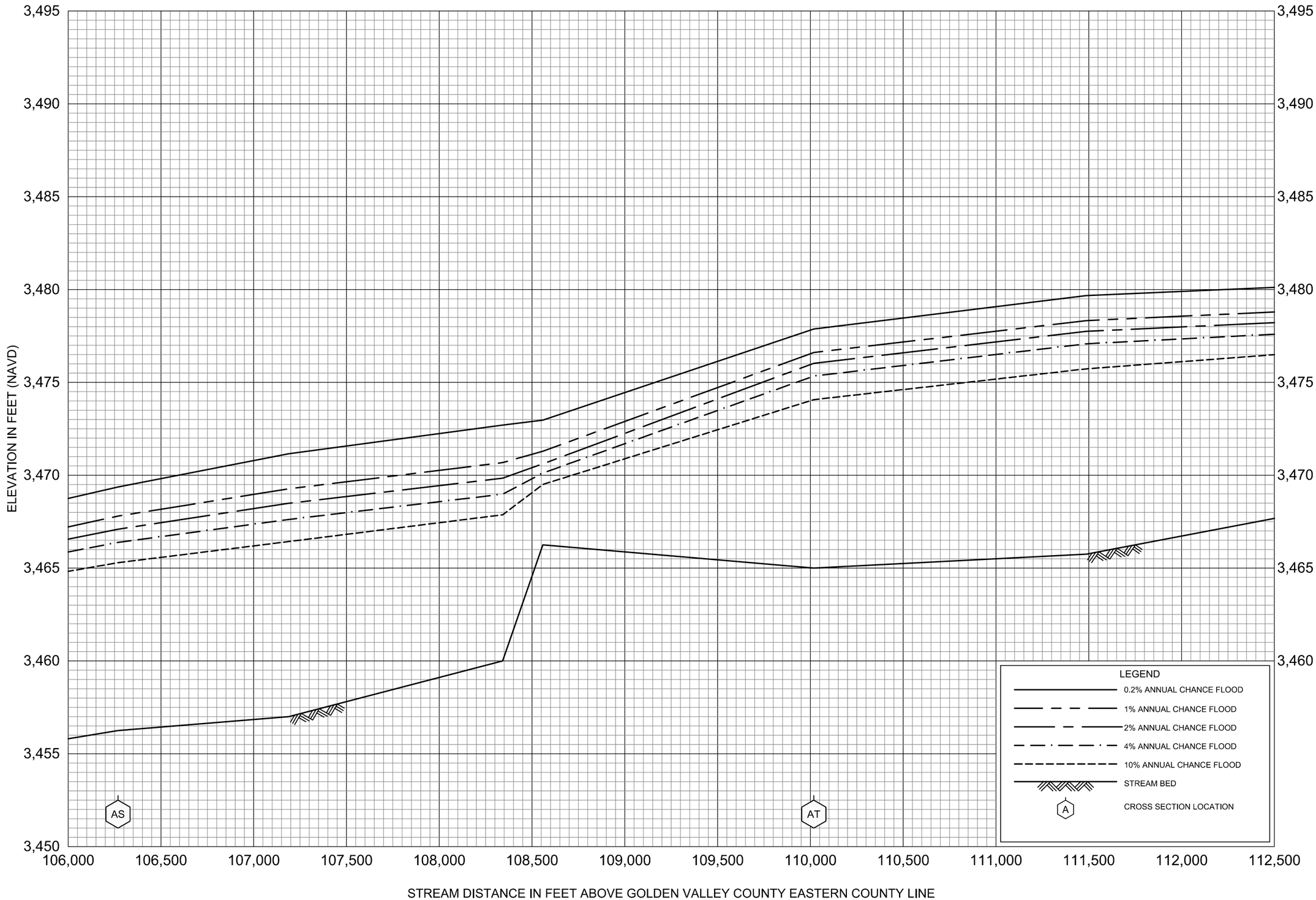

FLOOD PROFILES

MUSSELSHELL RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GOLDEN VALLEY COUNTY, MT

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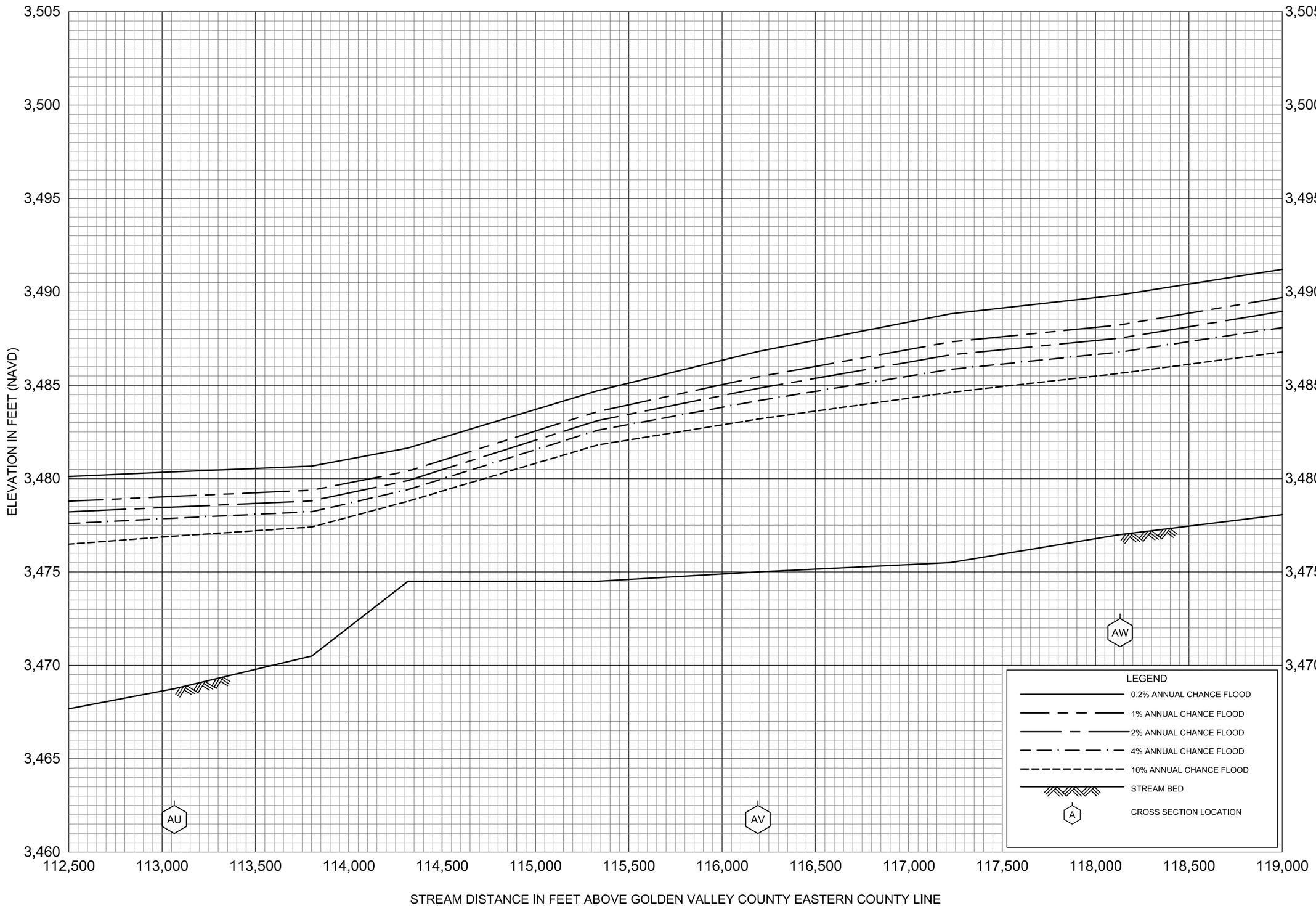

FLOOD PROFILES

MUSSELSHELL RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GOLDEN VALLEY COUNTY, MT

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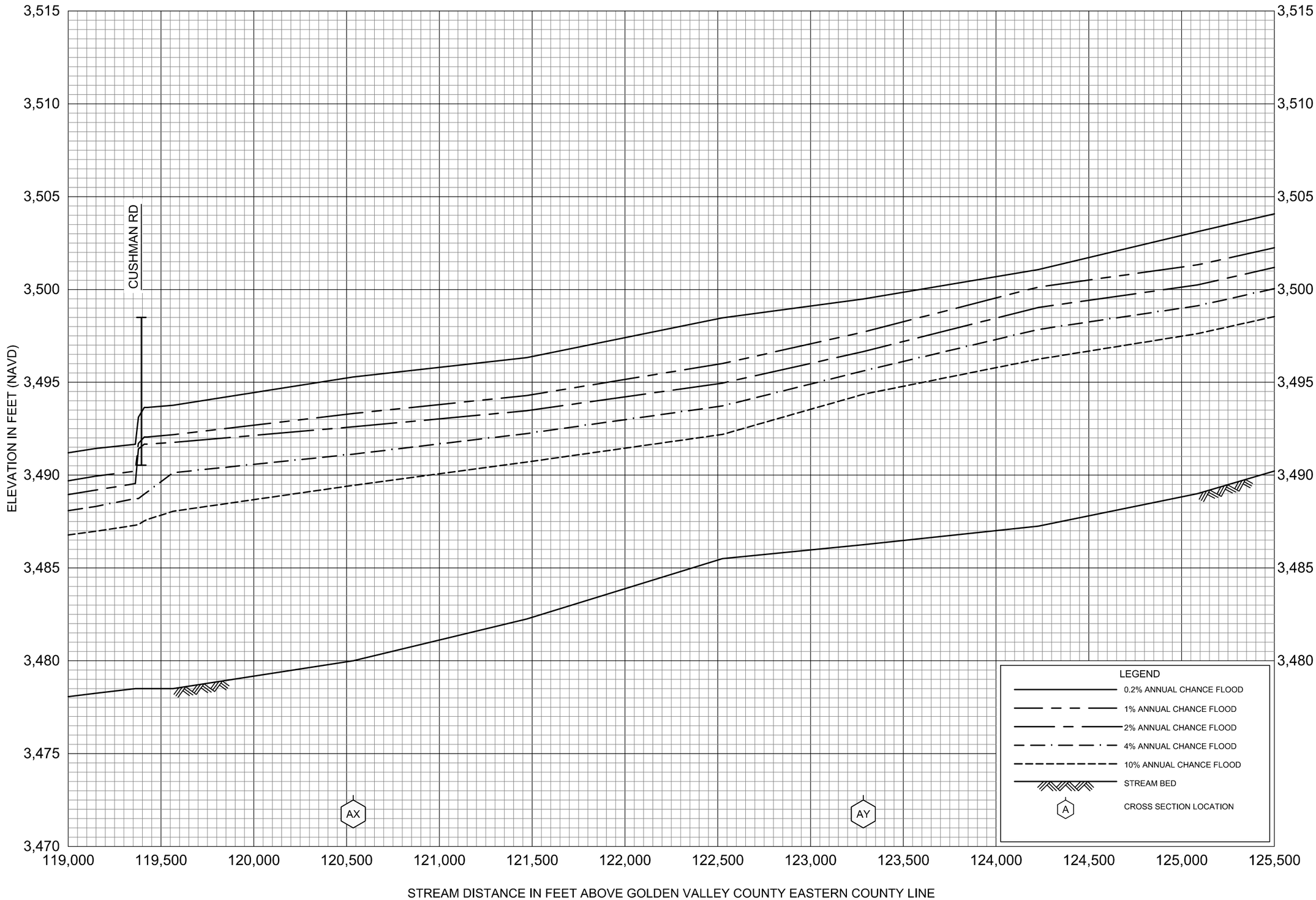


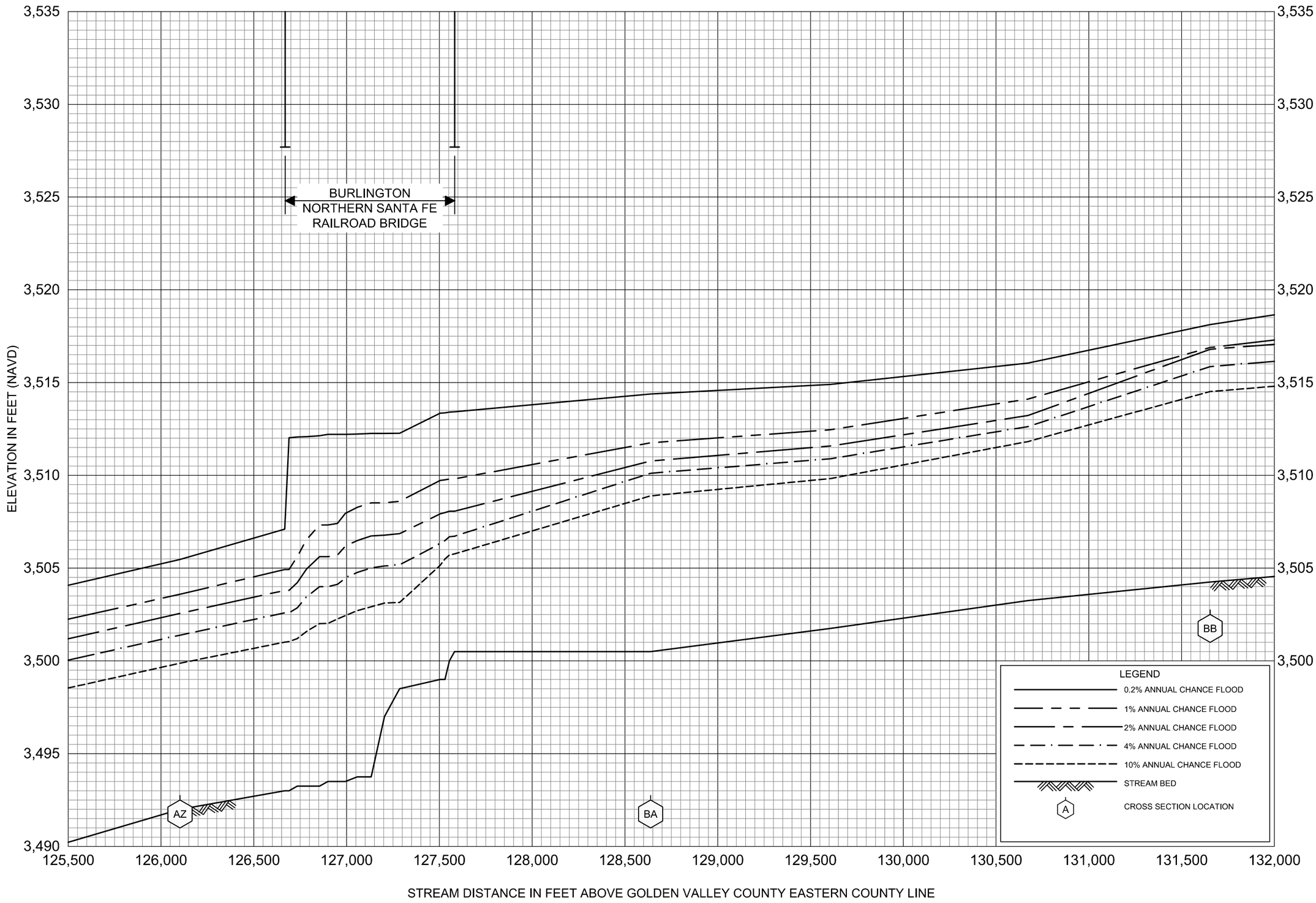
FLOOD PROFILES

MUSSELSHELL RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GOLDEN VALLEY COUNTY, MT

AND INCORPORATED AREAS



FLOOD PROFILES

MUSSELSHELL RIVER

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GOLDEN VALLEY COUNTY, MT

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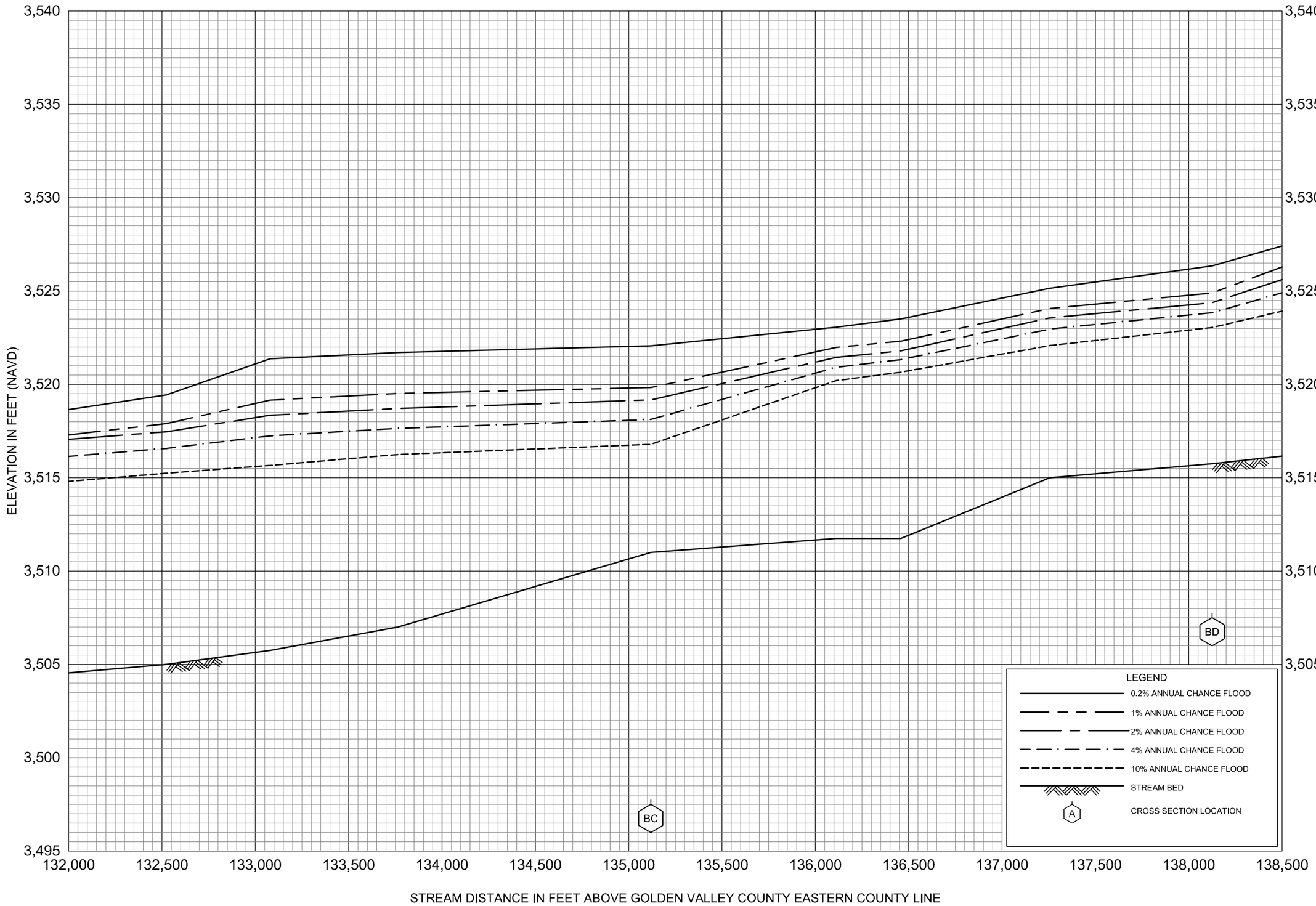

FLOOD PROFILES

MUSSELSHELL RIVER

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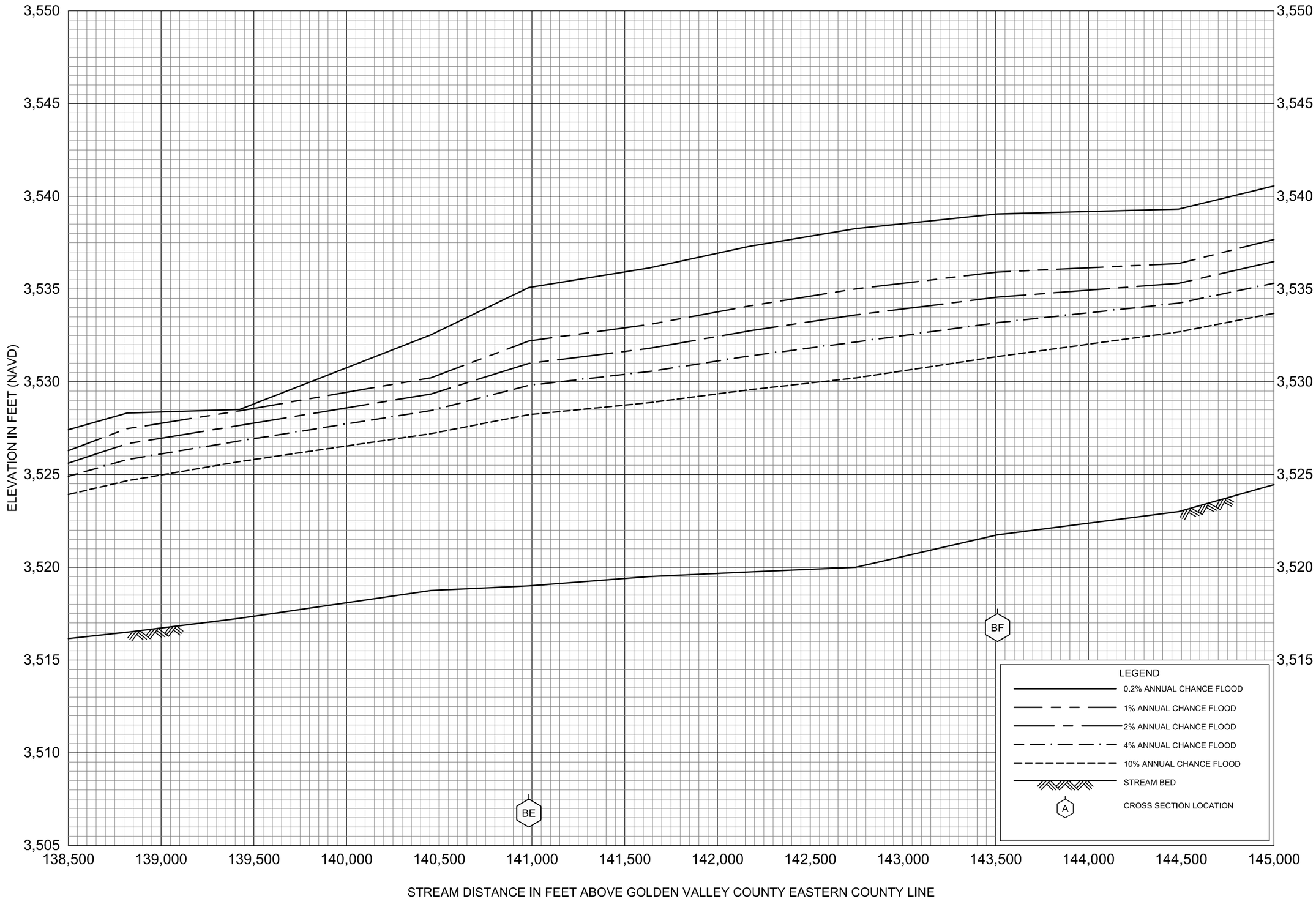
GOLDEN VALLEY COUNTY, MT

AND INCORPORATED AREAS



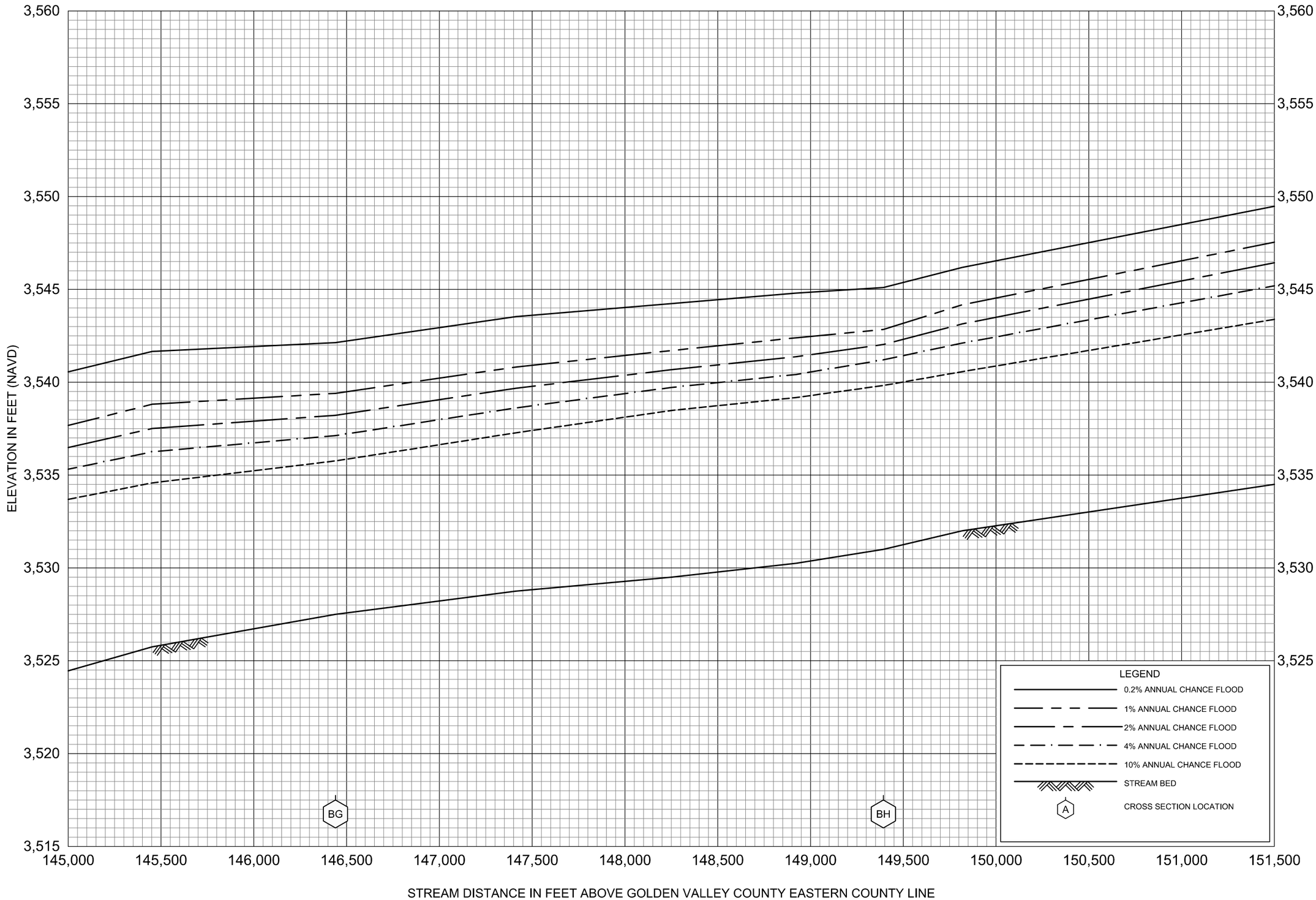
FLOOD PROFILES

MUSSELSHELL RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GOLDEN VALLEY COUNTY, MT

AND INCORPORATED AREAS



FLOOD PROFILES

MUSSELSHELL RIVER

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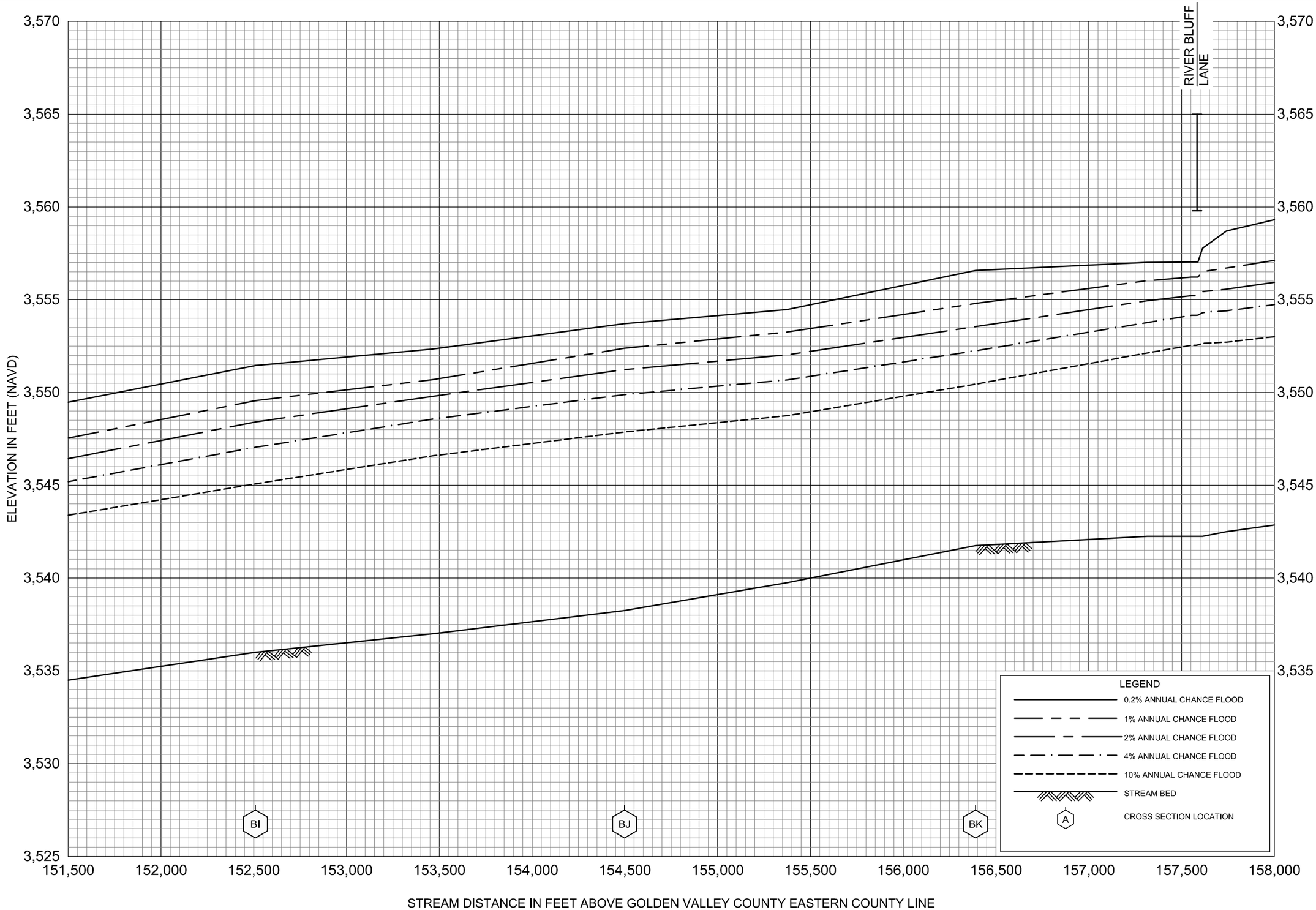

FLOOD PROFILES

MUSSELSHELL RIVER

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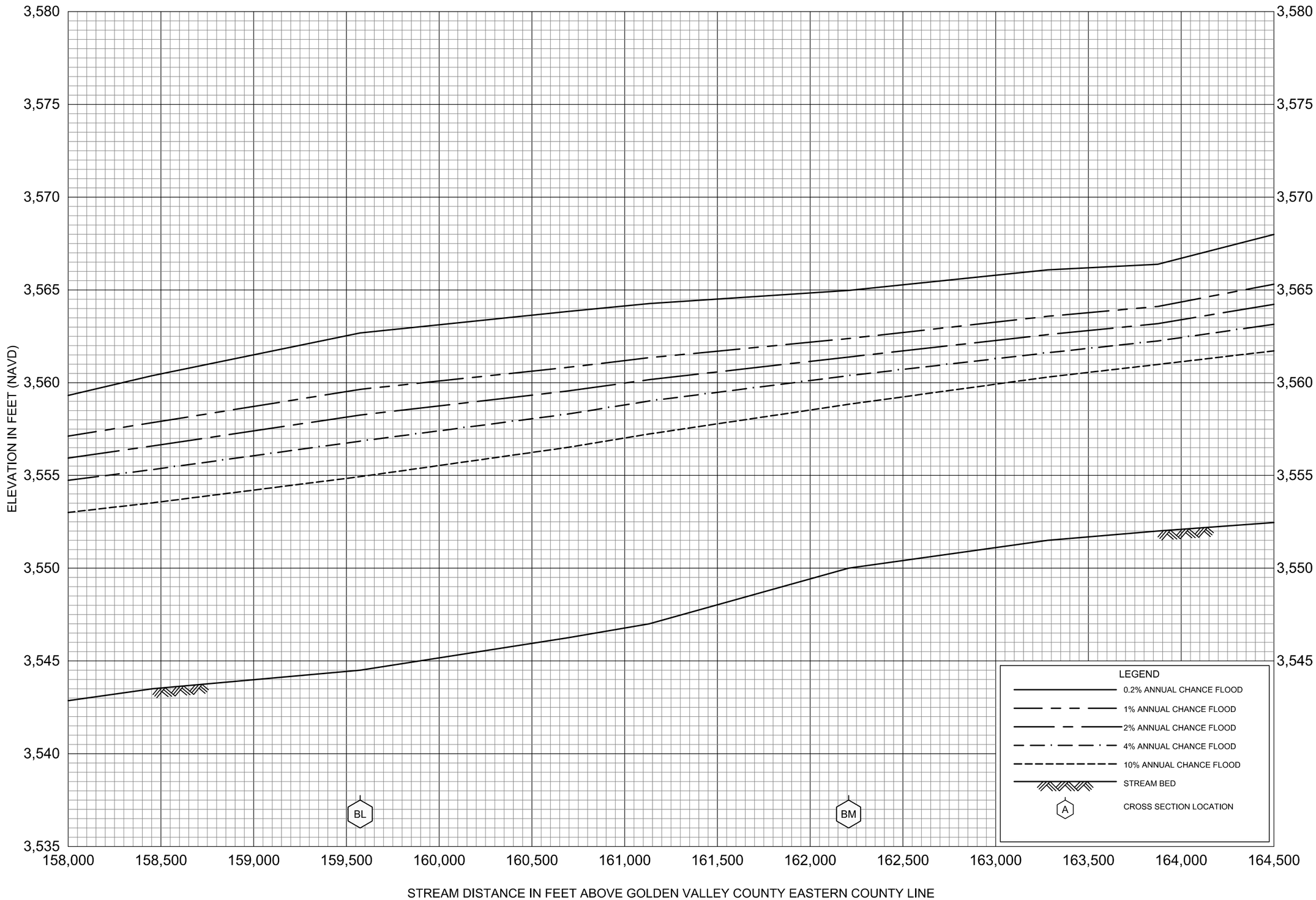

FLOOD PROFILES

MUSSELSHELL RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GOLDEN VALLEY COUNTY, MT

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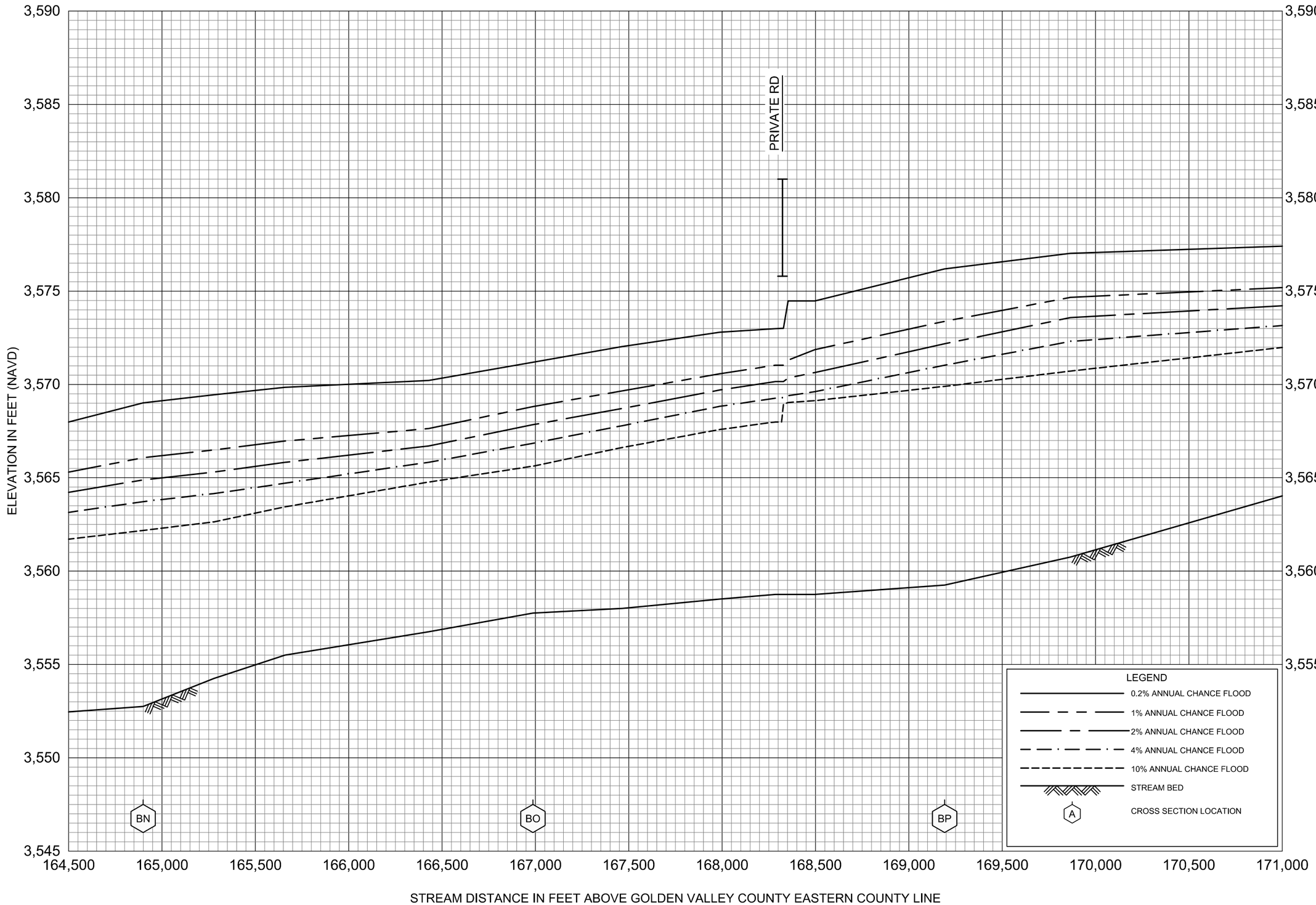


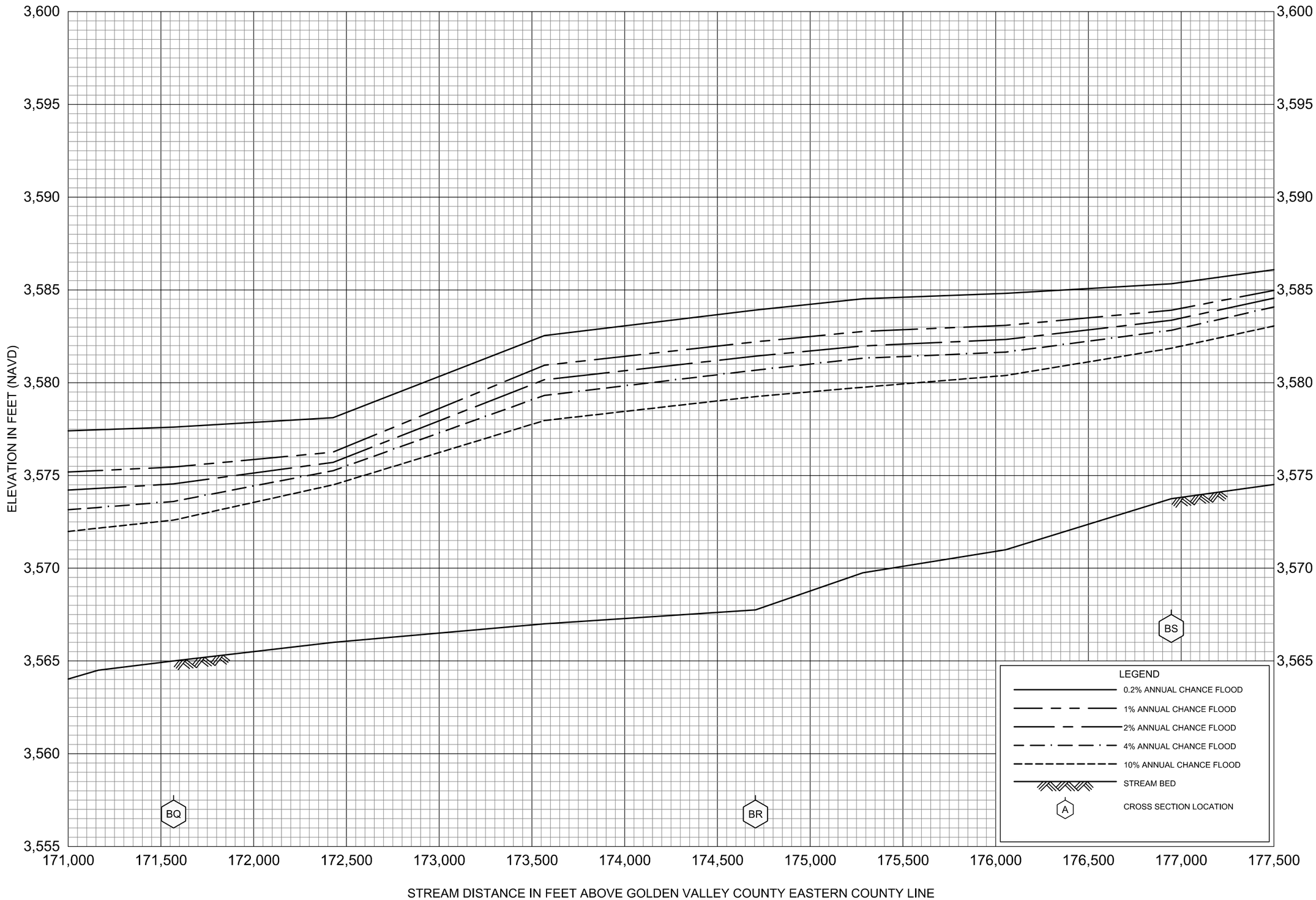
FLOOD PROFILES

MUSSELSHELL RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GOLDEN VALLEY COUNTY, MT

AND INCORPORATED AREAS



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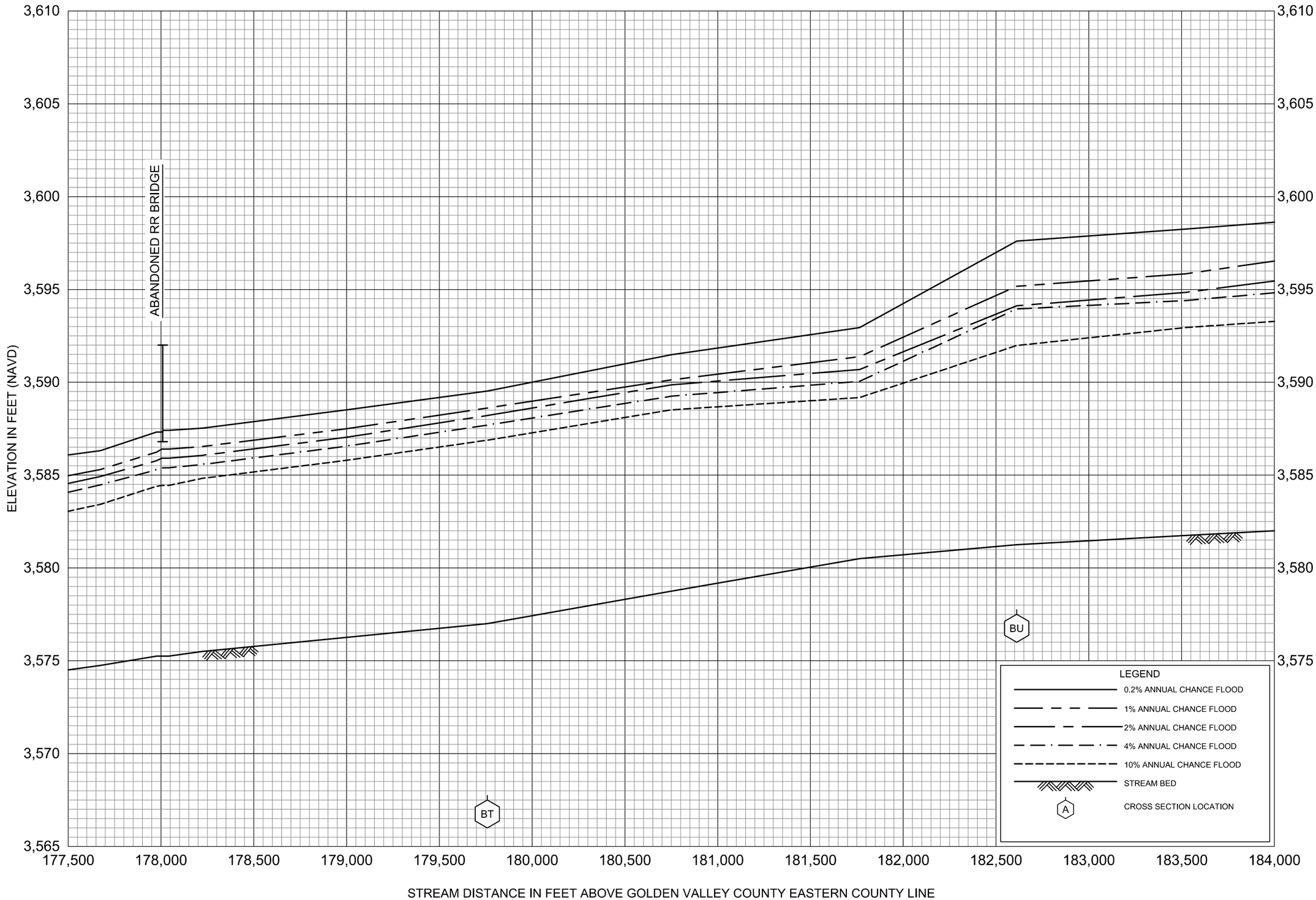

FLOOD PROFILES

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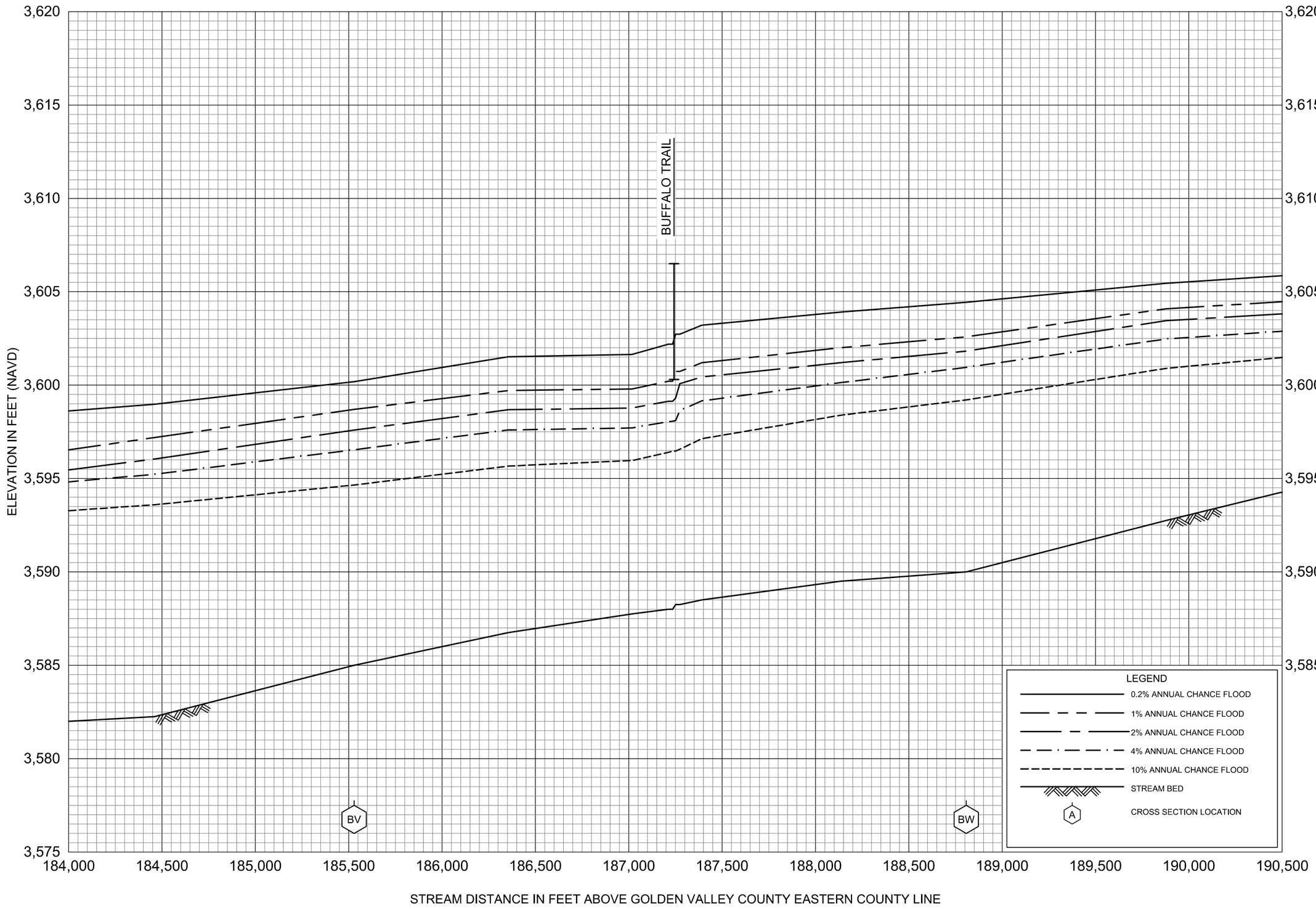

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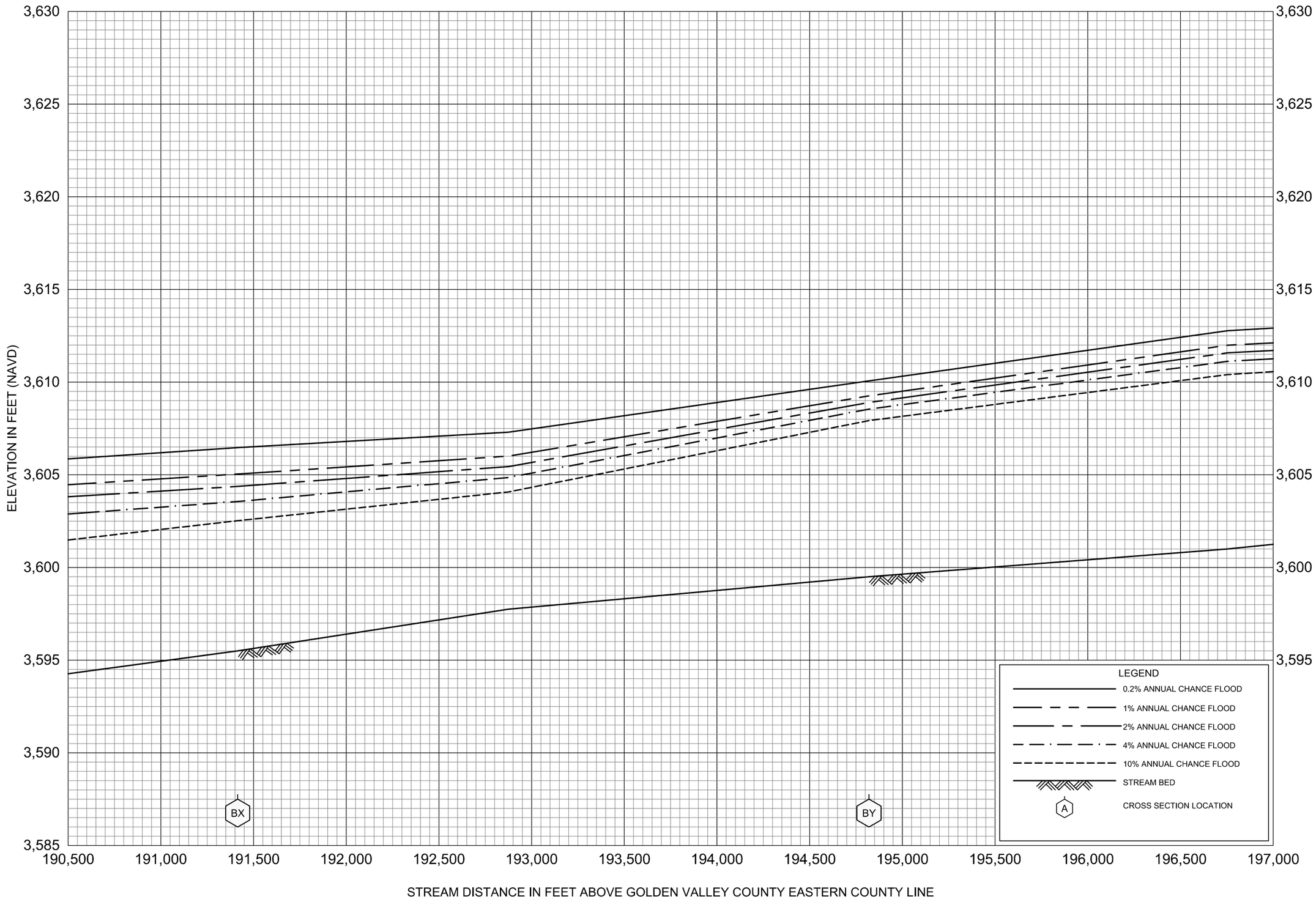

FLOOD PROFILES

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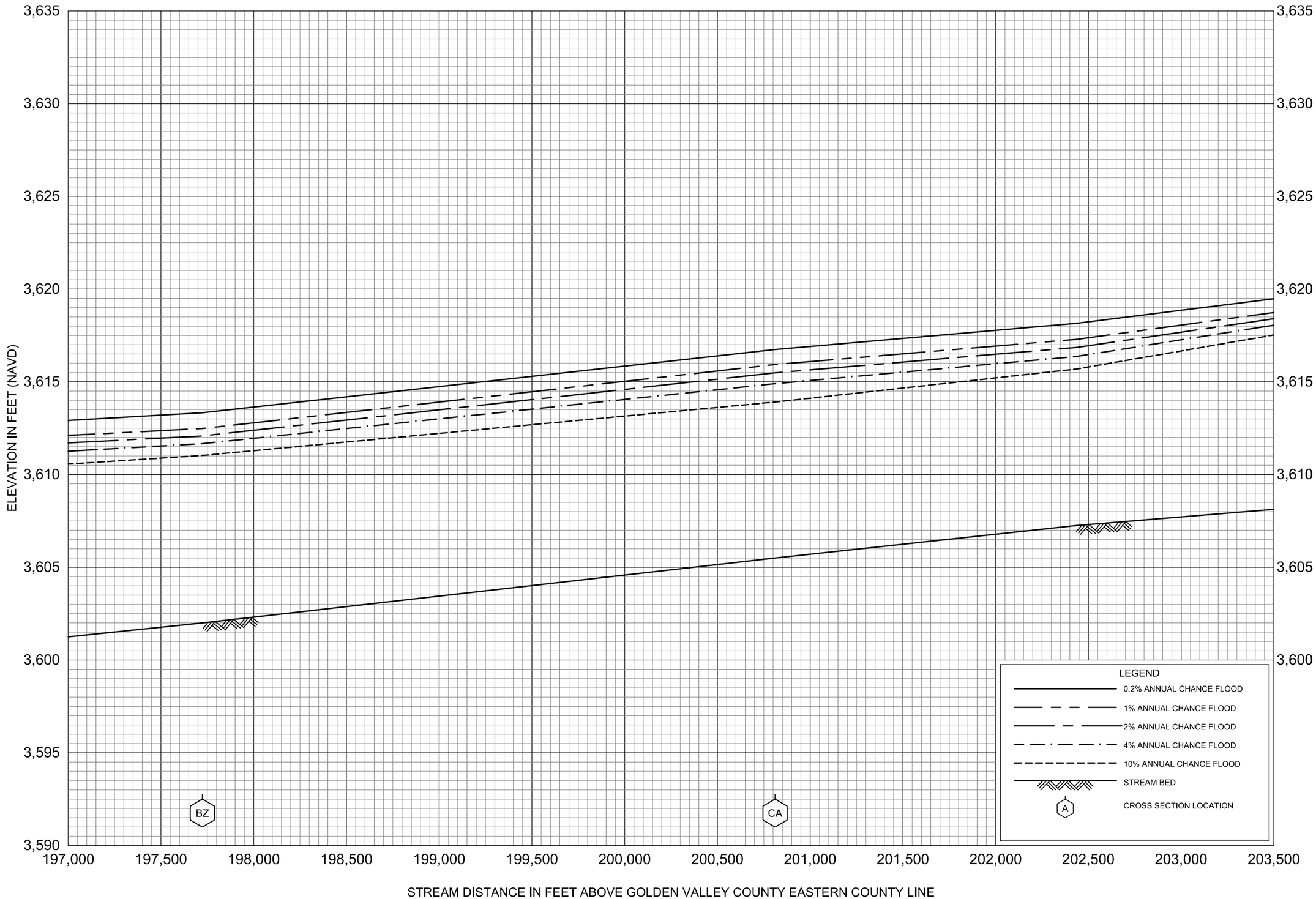

FLOOD PROFILES

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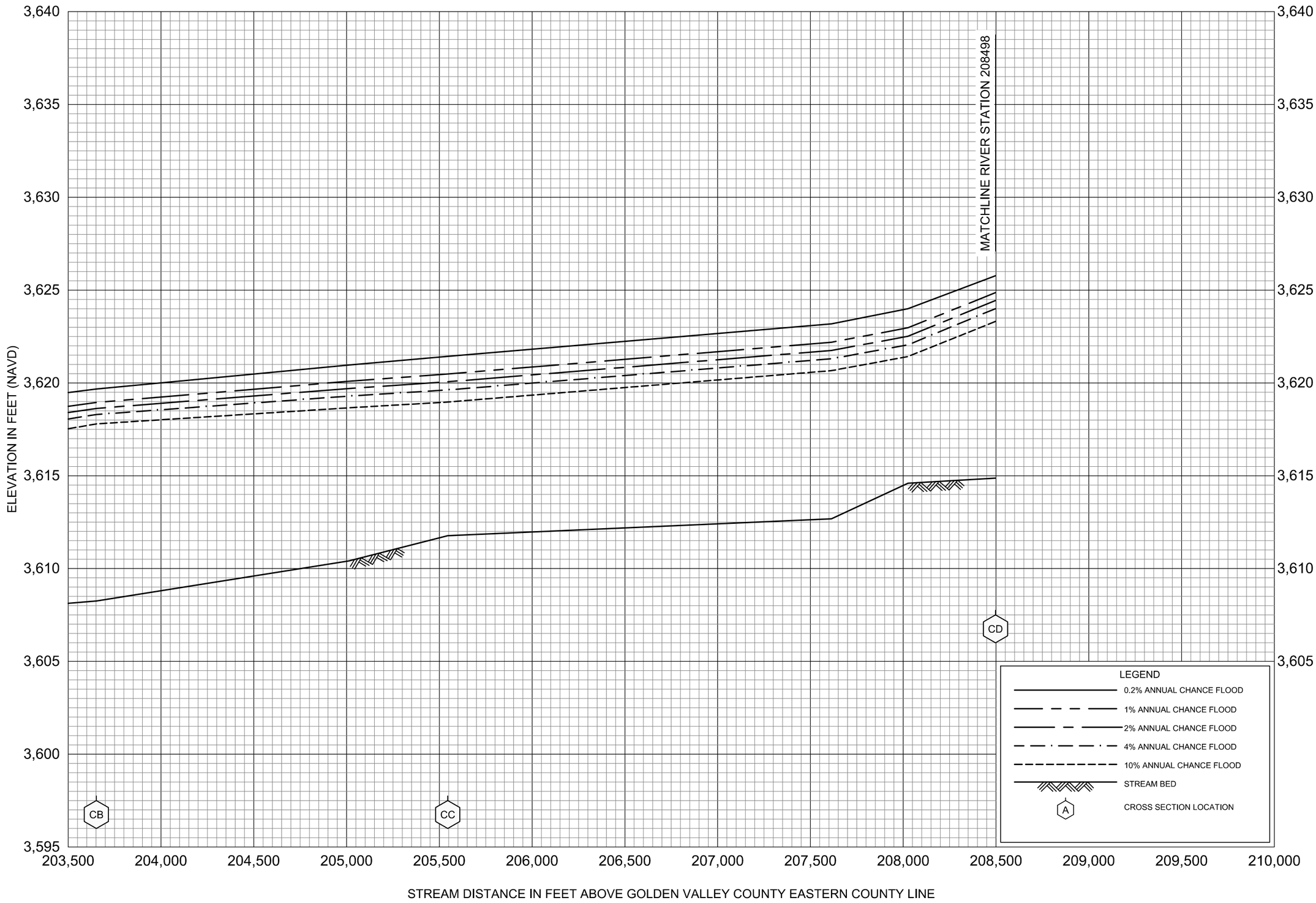

FLOOD PROFILES

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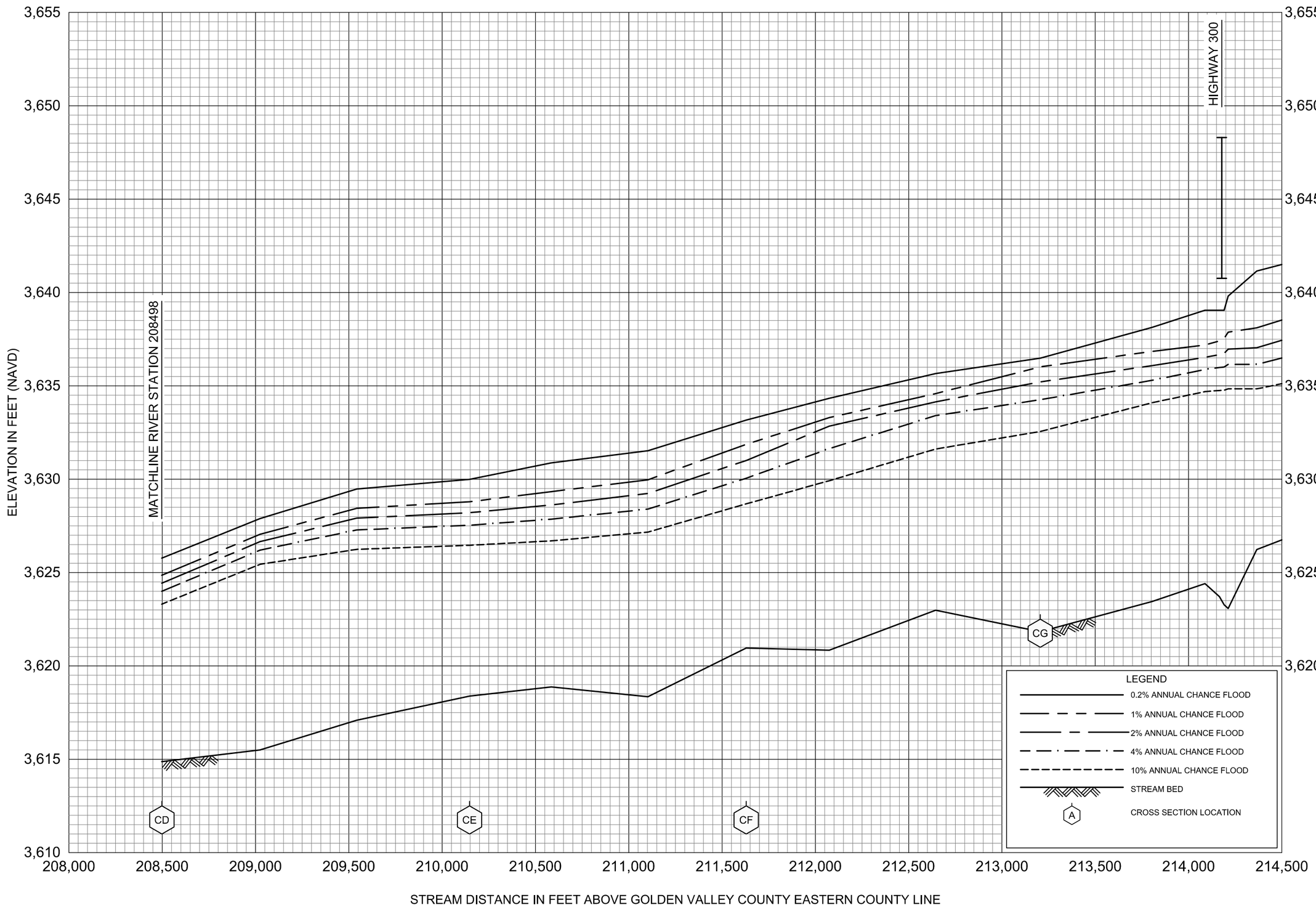

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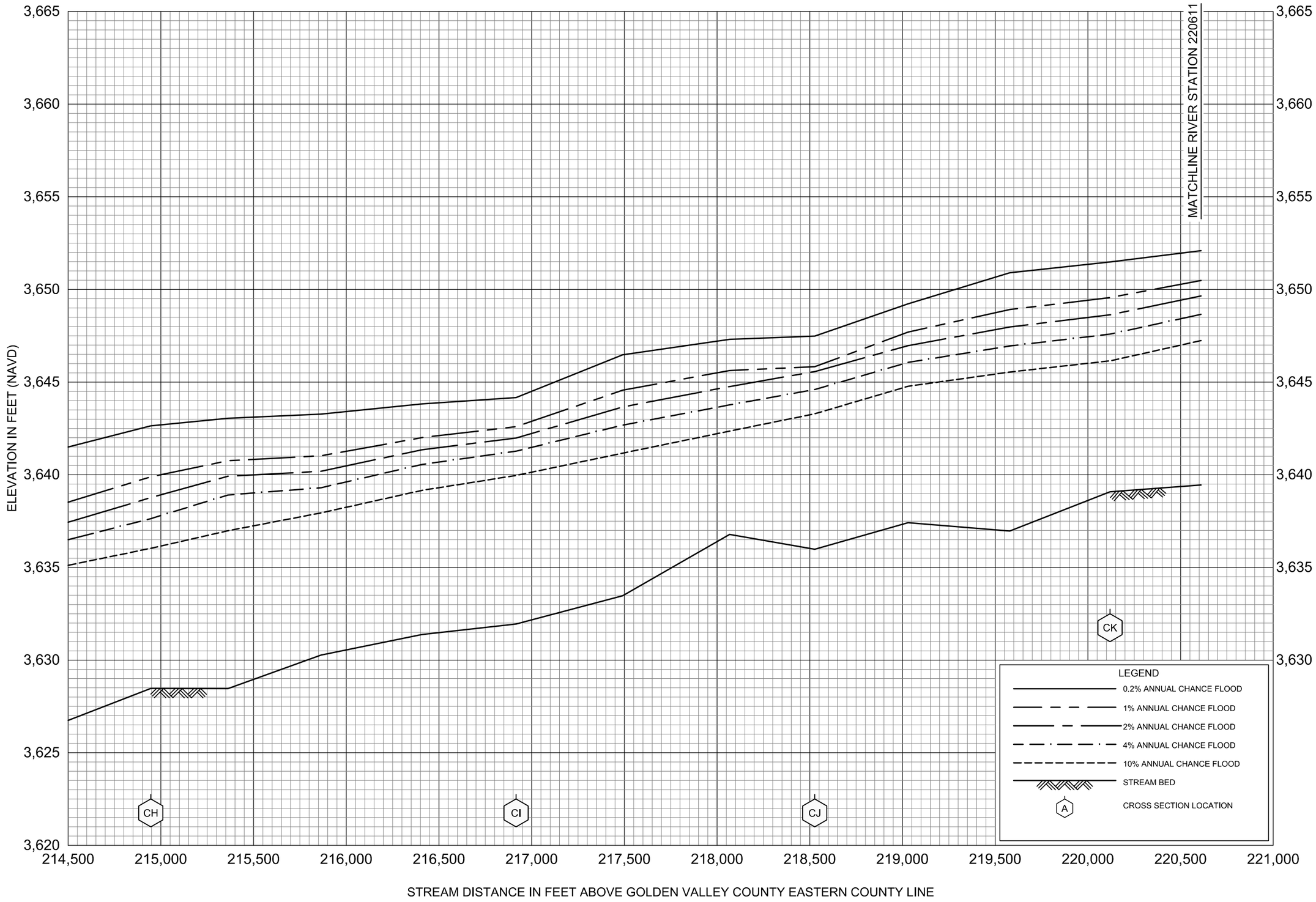

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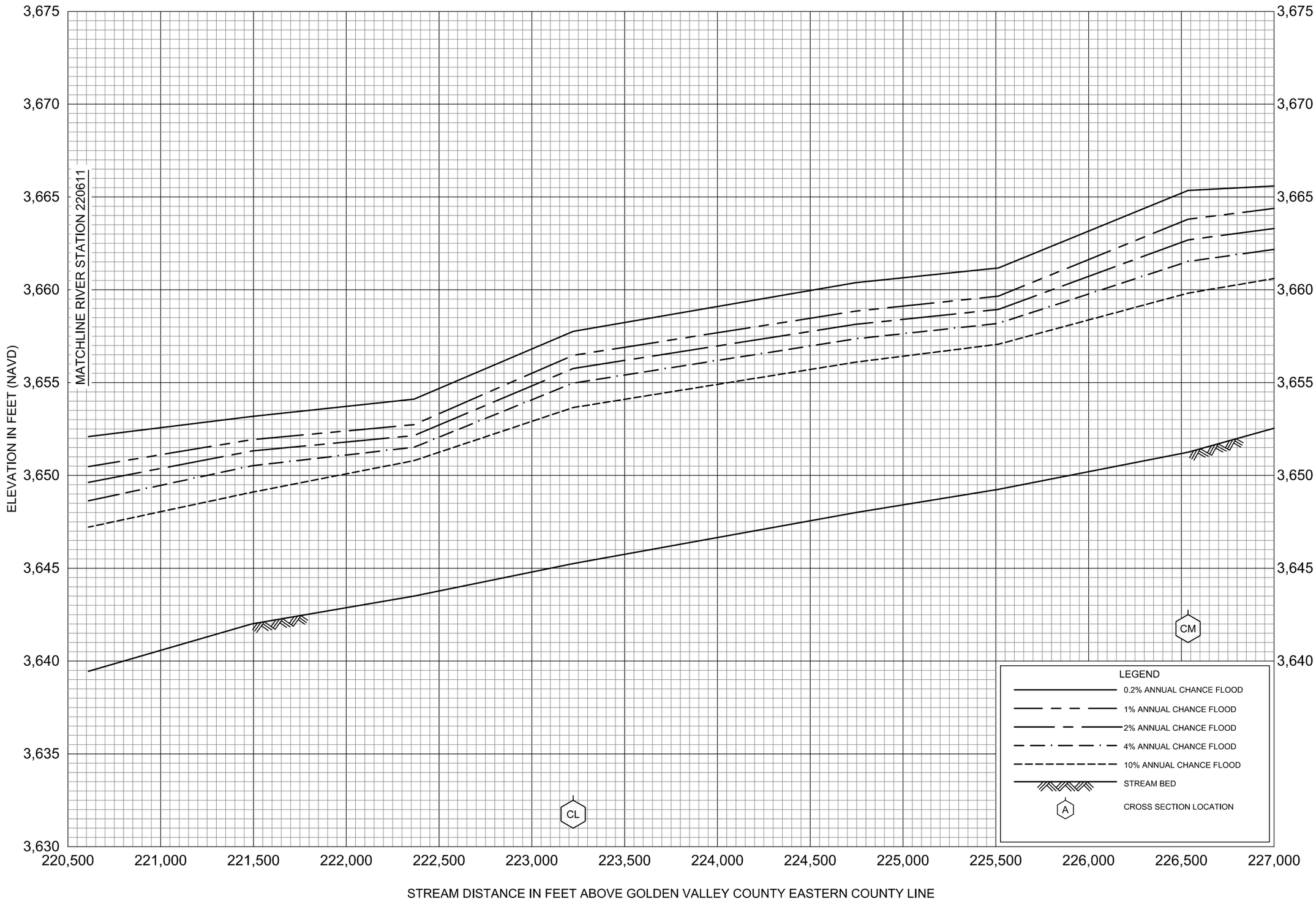

FLOOD PROFILES

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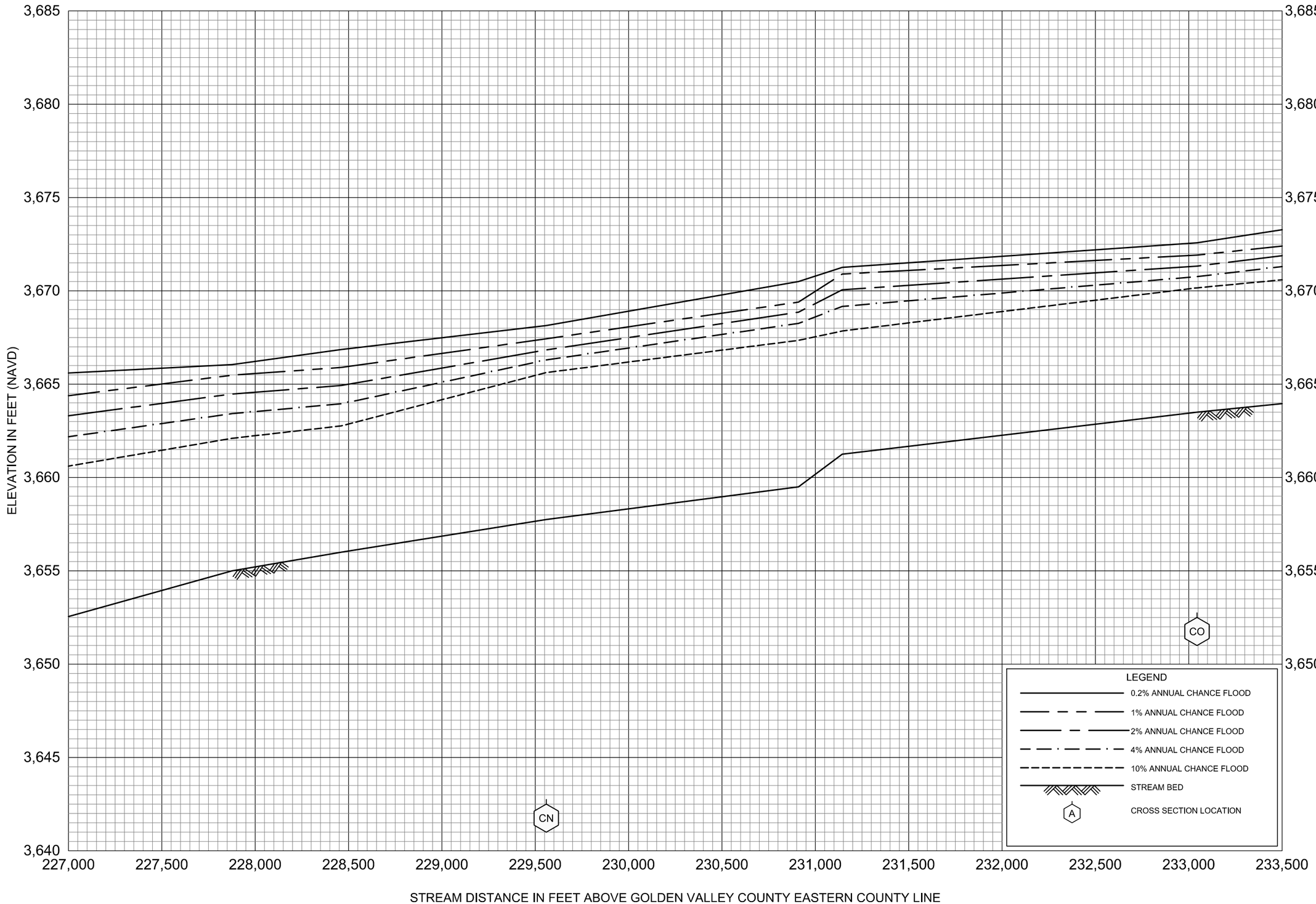

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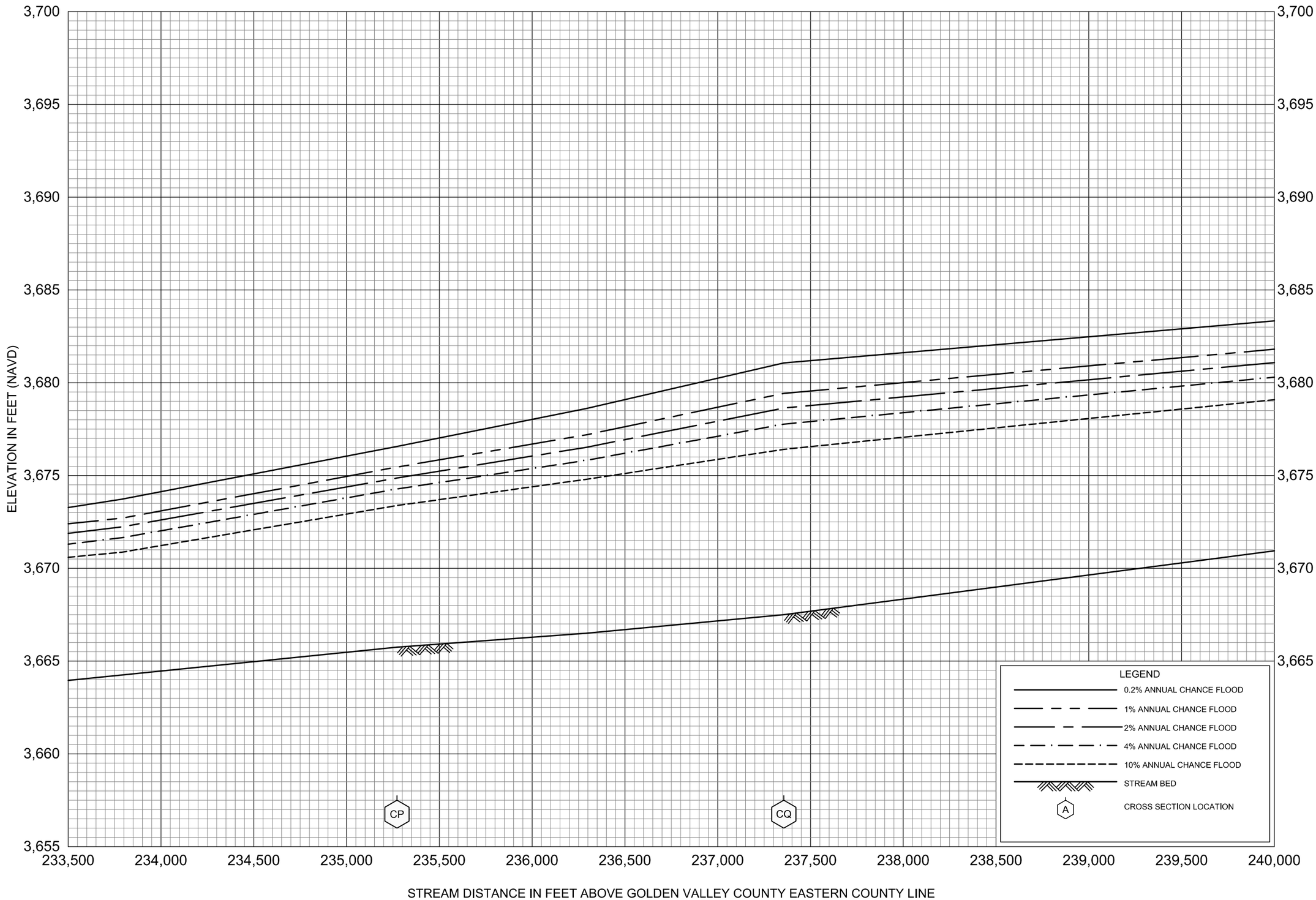

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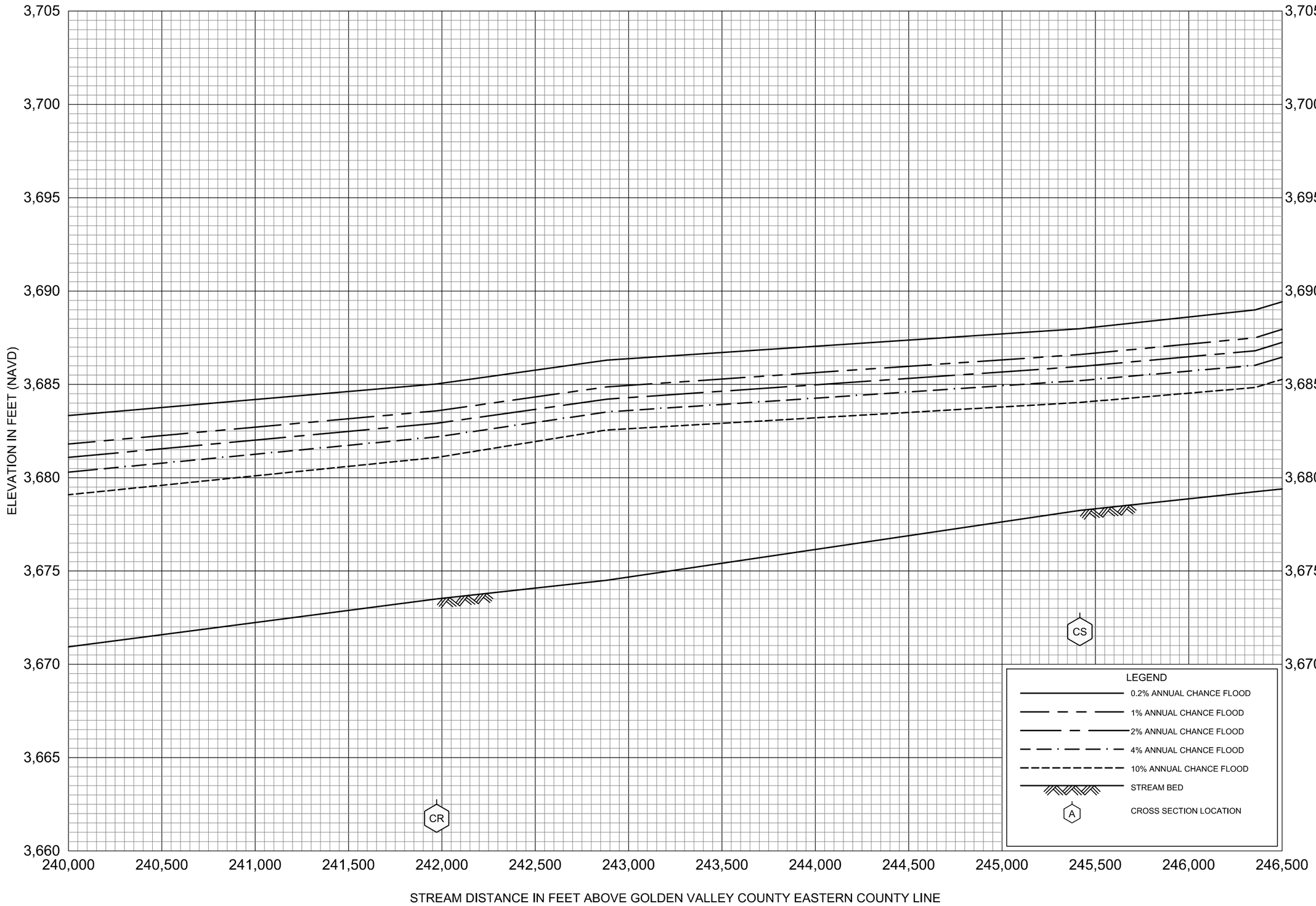

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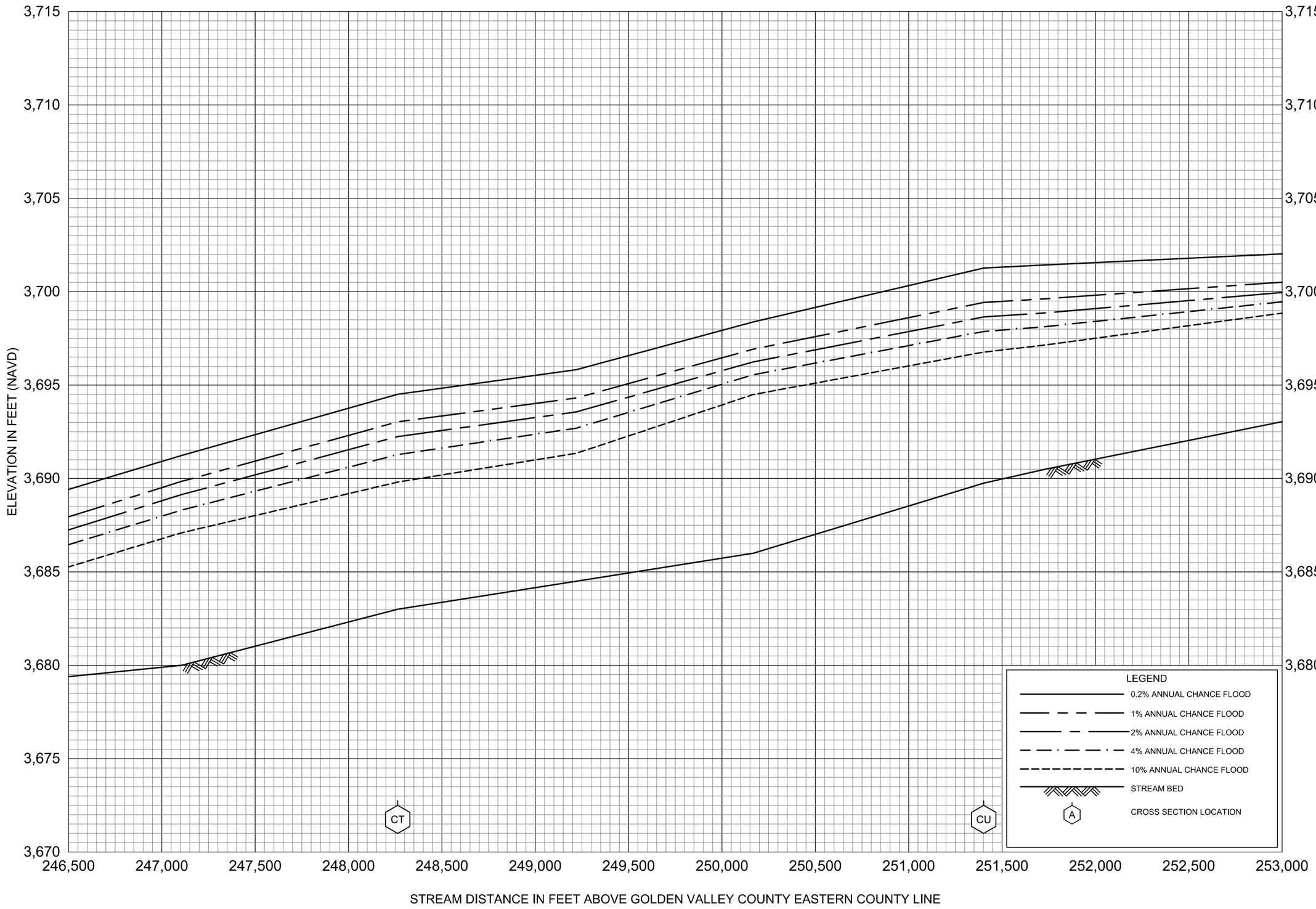

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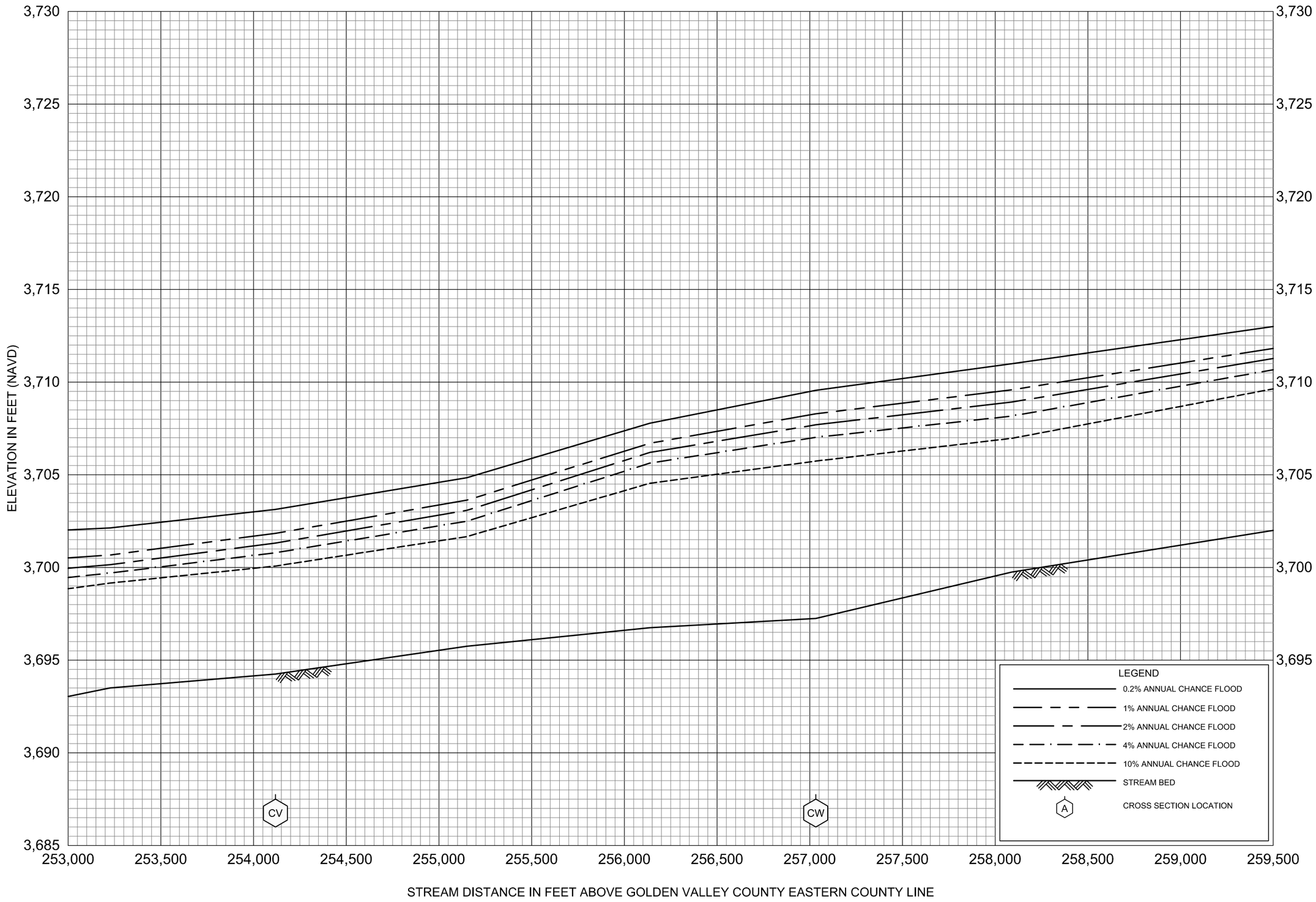

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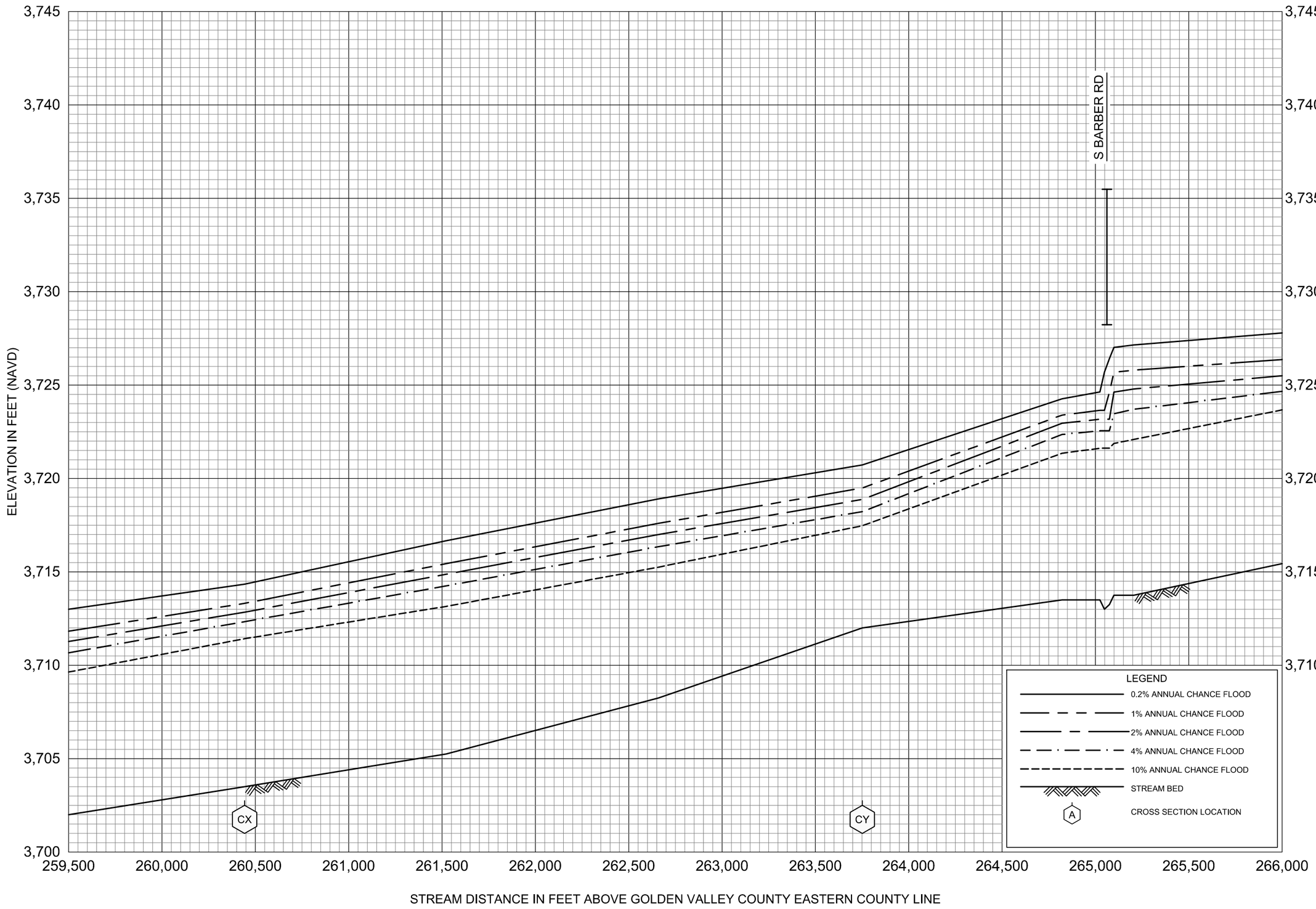

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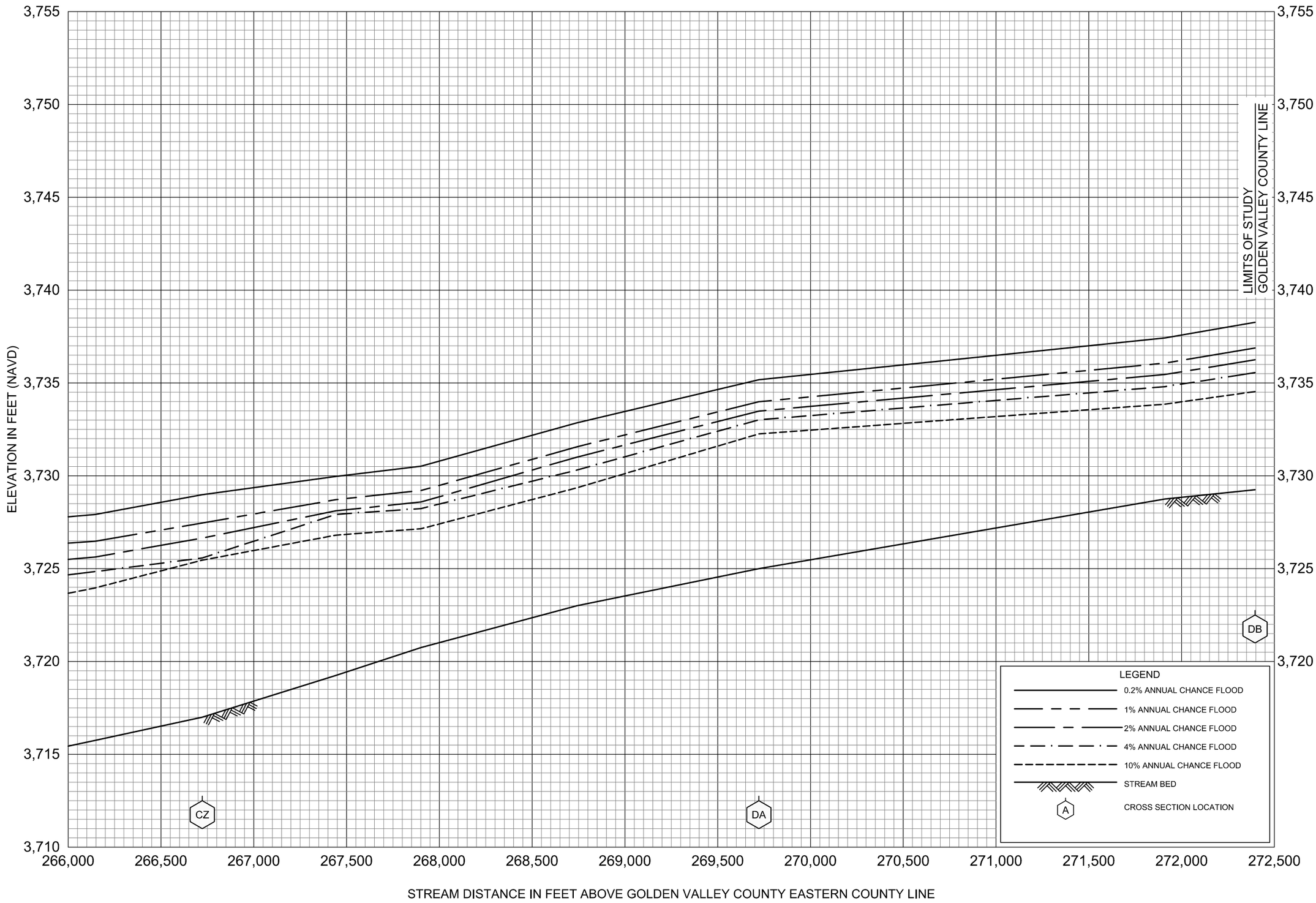


FLOOD PROFILES

MUSSELSHELL RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

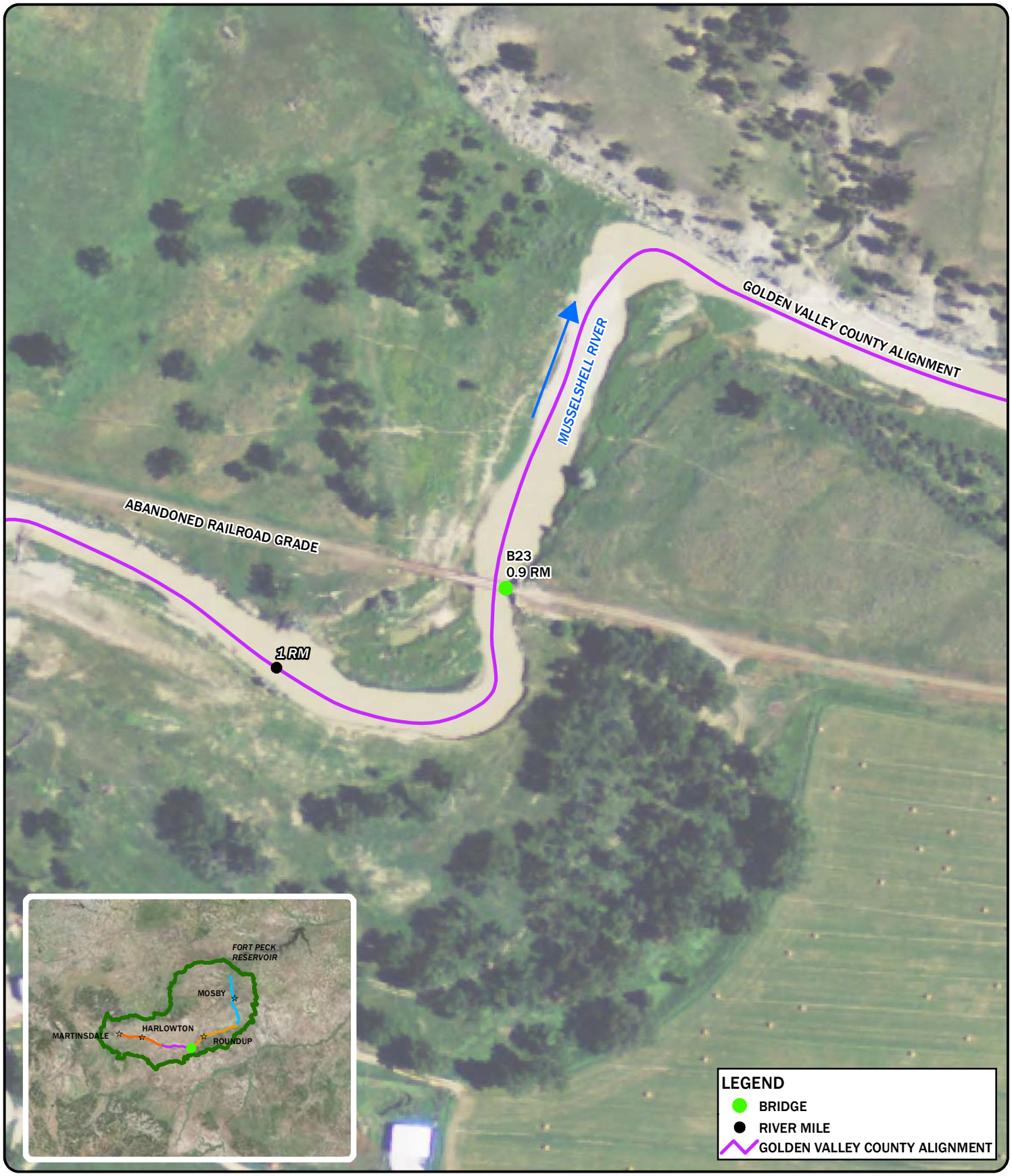
GOLDEN VALLEY COUNTY, MT

AND INCORPORATED AREAS

Appendix C – Bridge Structure Photographs

Golden Valley County
Musselshell River Bridge Structure Photographs
Mapping Activity Statement (MAS): No 2015-02

ID No.	Location	River Reach	River Station	Spans	Total Span (feet)	Pages
B23	Private Road	2	4750	2	182	1, 2, 3
B24	Private Road	2	34266	2	164	4, 5, 6
B25	State Highway 3	7	72493	3	145	7, 8, 9
B26	Cushman Road	2	119394	1	119	10, 11, 12
B27	Burlington Northern Santa Fe Railroad	2	126669 to 127287	12	782	13, 14, 15, 16, 17, 18
B28	Private Road	2	156388	n/a	n/a	19
B29	River Bluff Lane	2	157583	2	122	20
B30	Private Road	2	168319	2	160	21
B31	Abandon Railroad	2	177997	2	164	22, 23, 24
B32	Buffalo Trail	2	187234	1	168	25, 26, 27
B33	MT Highway 300	8	208498	2	144	28, 29, 30
B34	S Barber Road	2	265062	1	119	31, 32, 33



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PROJ./ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/RATT/NRIS/NAIP 2013

0 100 200 400
Feet

FIGURE B23

PIONEER TECHNICAL SERVICES, INC.

MUSSELSHELL RIVER
STRUCTURE INVENTORY
B23

DATE: 11/2/2014

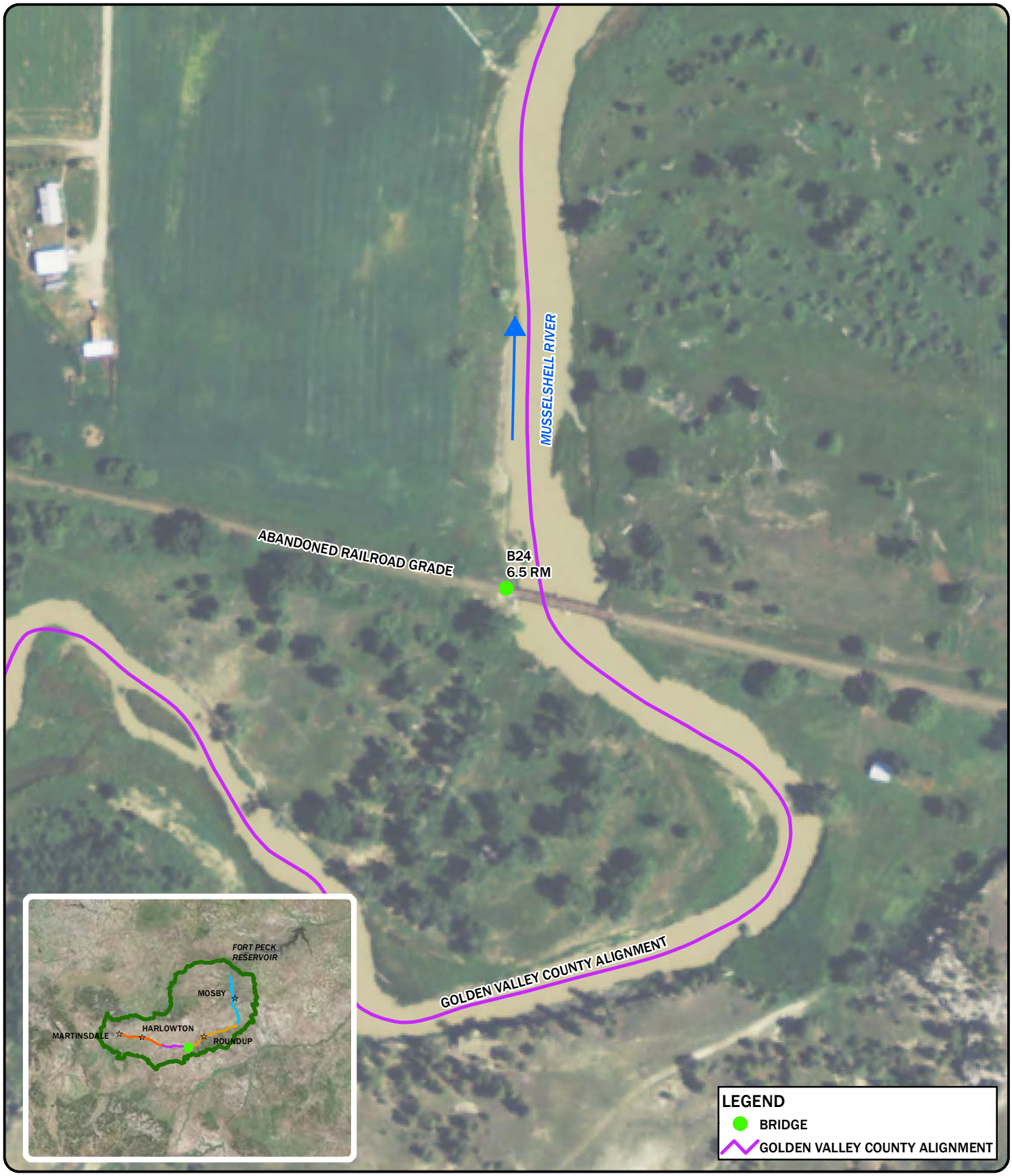
Path: P:\DNRC\Musselshell\GIS\Project\StructureInventory_Draft\B23-figure.mxd

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AM
	Date: 8/27/2014
	Description: Looking downstream from B23 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AN
	Date: 8/27/2014
	Description: Looking upstream from B23 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AO
	Date: 8/27/2014
	Description: Looking upstream at B23 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AP
	Date: 8/27/2014
	Description: Looking downstream at B23 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1



DISPLAYED AS:
PROJ./ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/RATT/NRIS/NAIP 2013

0 100 200 400
Feet

FIGURE B24

PIONEER TECHNICAL SERVICES, INC.

MUSSELSHELL RIVER
STRUCTURE INVENTORY
B24

DATE: 11/2/2014

Path: P:\DNRC\Musselshell\GIS\Project\StructureInventory_Draft\B24-figure.mxd

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AE
	Date: 8/27/2014
	Description: Looking upstream at B24 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AF
	Date: 8/27/2014
	Description: Looking upstream from B24 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AG
	Date: 8/27/2014
	Description: Looking downstream from B24 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AH
	Date: 8/27/2014
	Description: Looking downstream at B24 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

DISPLAYED AS:
PROJ./ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/RATT/NRIS/NAIP 2013

0 100 200 400
Feet

FIGURE B25

PIONEER TECHNICAL SERVICES, INC.

MUSSELSHELL RIVER
STRUCTURE INVENTORY
B25

DATE: 11/2/2014

Path: P:\DNRC\Musselshell\GIS\Project\StructureInventory_Draft\B25-figure.mxd

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AI
	Date: 8/27/2014
	Description: Looking downstream at B25 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AJ
	Date: 8/27/2014
	Description: Looking upstream from B25 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AK
	Date: 8/27/2014
	Description: Looking downstream from B25 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AL
	Date: 8/27/2014
	Description: Looking upstream at B25 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

DISPLAYED AS:
PROJ./ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/RATT/NRIS/NAIP 2013

0 100 200 400
Feet

FIGURE B26

PIONEER TECHNICAL SERVICES, INC.

MUSSELSHELL RIVER
STRUCTURE INVENTORY
B26

DATE: 11/2/2014

Path: P:\DNRC\Musselshell\GIS\Project\StructureInventory_Draft\B26-figure.mxd

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AS
	Date: 8/27/2014
	Description: Looking upstream at B26 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AT
	Date: 8/27/2014
	Description: Looking downstream at B26 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AU
	Date: 8/27/2014
	Description: Looking downstream from B26 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AV
	Date: 8/27/2014
	Description: Looking upstream from B26 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

DISPLAYED AS:
PROJ./ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/RATT/NRIS/NAIP 2013

0 100 200 400
Feet

FIGURE B27

PIONEER TECHNICAL SERVICES, INC.

MUSSELSHELL RIVER
STRUCTURE INVENTORY
B27

DATE: 11/2/2014

Path: P:\DNRC\Musselshell\GIS\Project\StructureInventory_Draft\B27-figure.mxd

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AW
	Date: 8/27/2014
	Description: Looking south east at the length of B27 bridge
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AX
	Date: 8/27/2014
	Description: Looking downstream at B27 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AY
	Date: 8/27/2014
	Description: Looking downstream at B27 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AZ
	Date: 8/27/2014
	Description: Looking downstream at B27 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BA
	Date: 8/27/2014
	Description: Looking downstream at B27 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BB
	Date: 8/27/2014
	Description: Looking upstream at B27 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BC
	Date: 8/27/2014
	Description: Looking upstream at B27 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BD
	Date: 8/27/2014
	Description: Looking upstream at B27 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BE
	Date: 8/27/2014
	Description: Looking upstream from B27 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BF
	Date: 8/27/2014
	Description: Looking downstream from B27 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

DISPLAYED AS:
PROJ./ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/RATT/NRIS/NAIP 2013

0 100 200 400
Feet

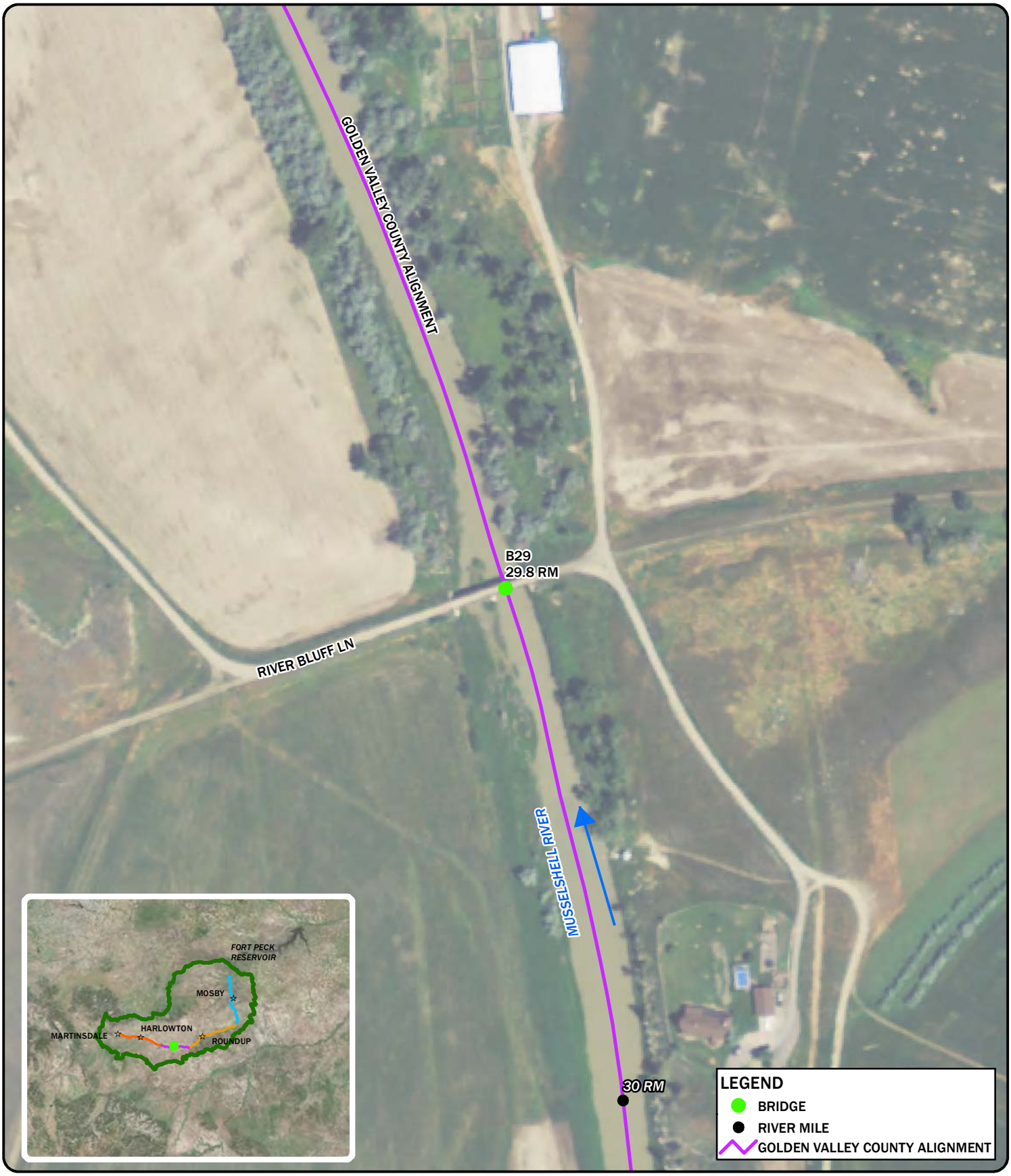
FIGURE B28

PIONEER TECHNICAL SERVICES, INC.

MUSSELSHELL RIVER
STRUCTURE INVENTORY
B28

DATE: 11/5/2014

Path: P:\DNRC\Musselshell\GIS\Project\StructureInventory_Draft\B28-figure.mxd



DISPLAYED AS:
PROJ./ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/RATT/NRIS/NAIP 2013

0 100 200 400
Feet

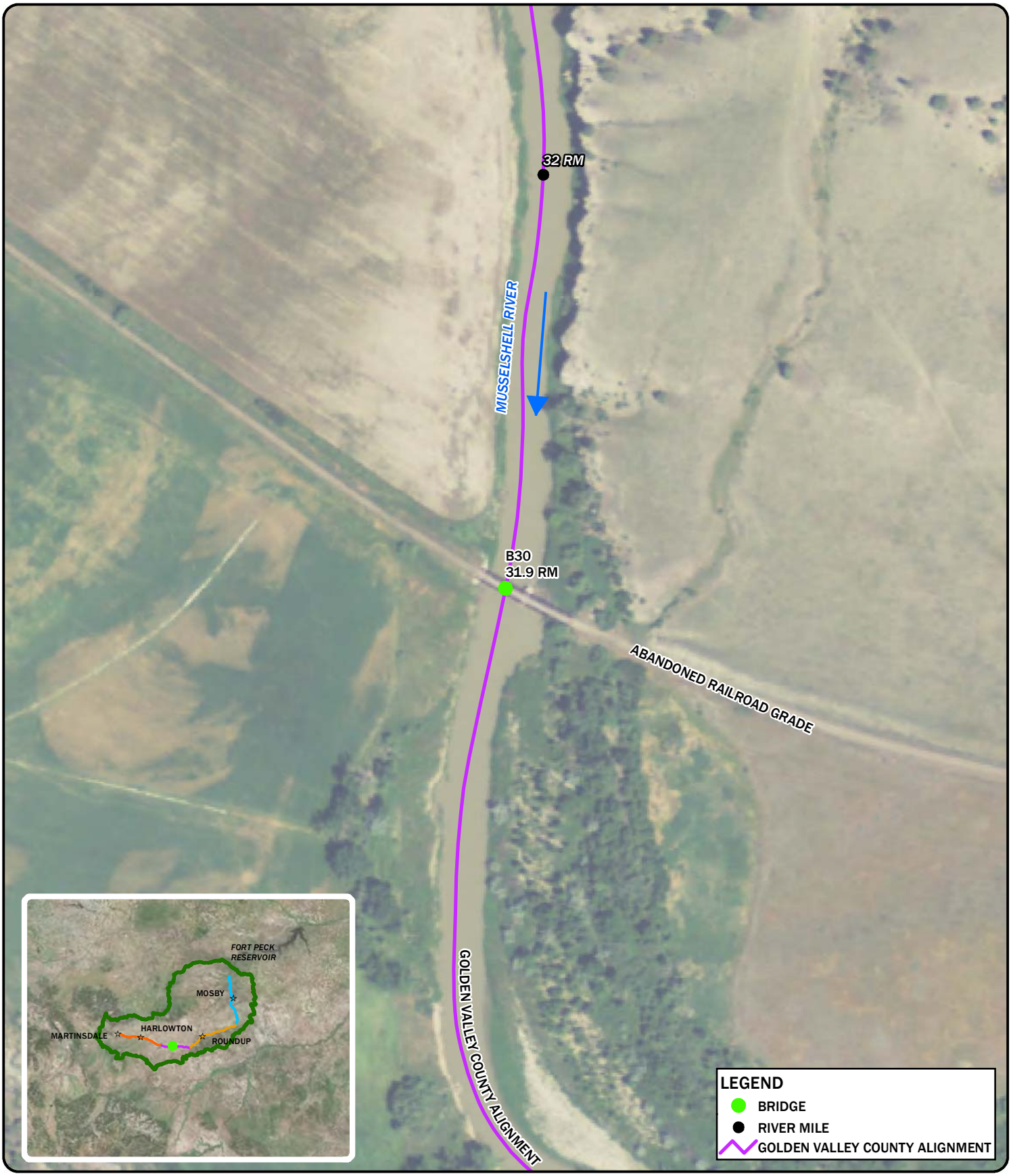
FIGURE B29

PIONEER TECHNICAL SERVICES, INC.

MUSSELSHELL RIVER
STRUCTURE INVENTORY
B29

DATE: 11/2/2014

Path: P:\DNRC\Musselshell\GIS\Project\StructureInventory_Draft\B29-figure.mxd



DISPLAYED AS:
PROJ./ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/RATT/NRIS/NAIP 2013

0 100 200 400
Feet

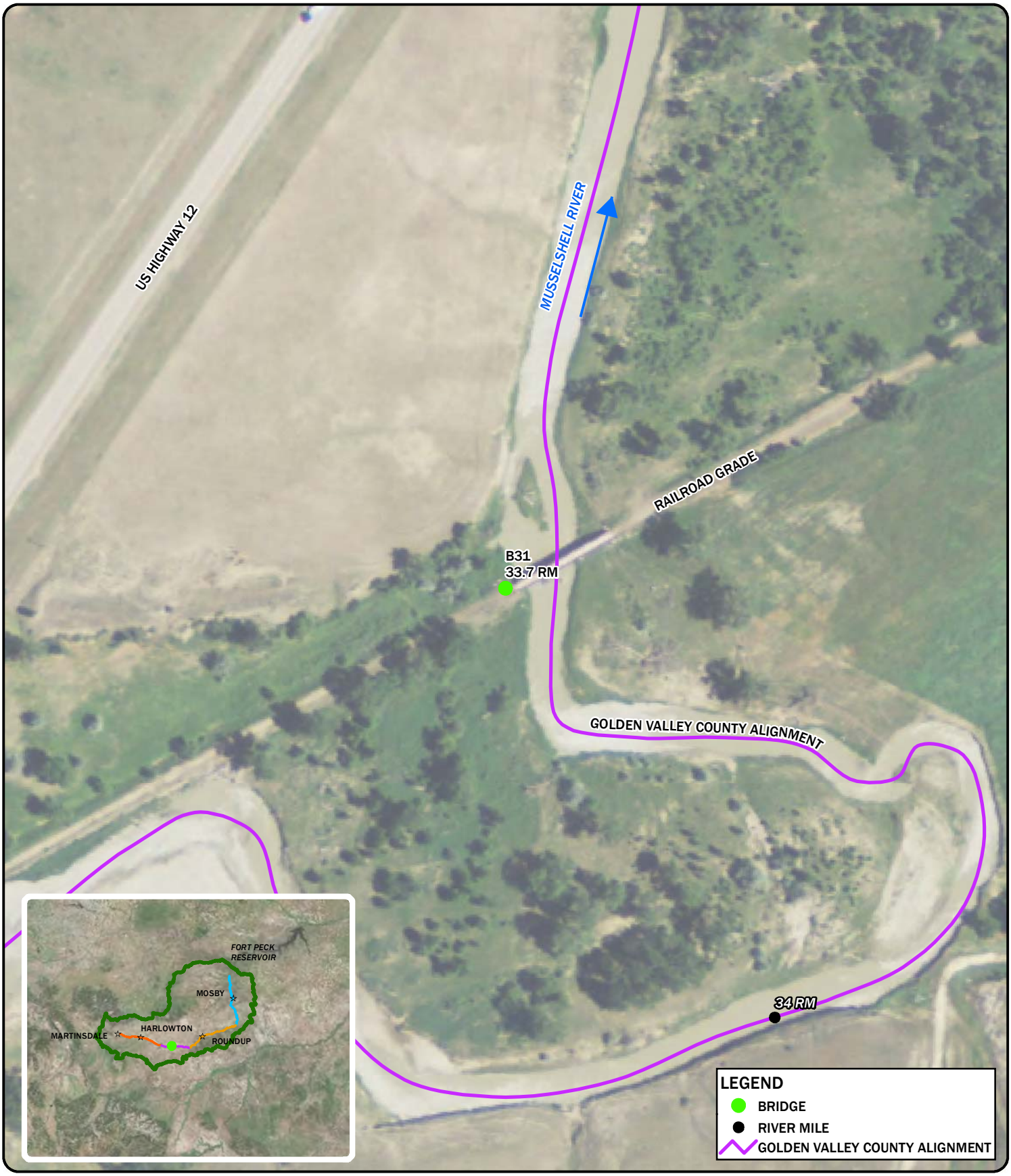
FIGURE B30

PIONEER TECHNICAL SERVICES, INC.

MUSSELSHELL RIVER
STRUCTURE INVENTORY
B30

DATE: 11/3/2014

Path: P:\DNRC\Musselshell\GIS\Project\StructureInventory_Draft\B30-figure.mxd



DISPLAYED AS:
PROJ./ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/RATT/NRIS/NAIP 2013

0 100 200 400
Feet

FIGURE B31

PIONEER TECHNICAL SERVICES, INC.

MUSSELSHELL RIVER
STRUCTURE INVENTORY
B31

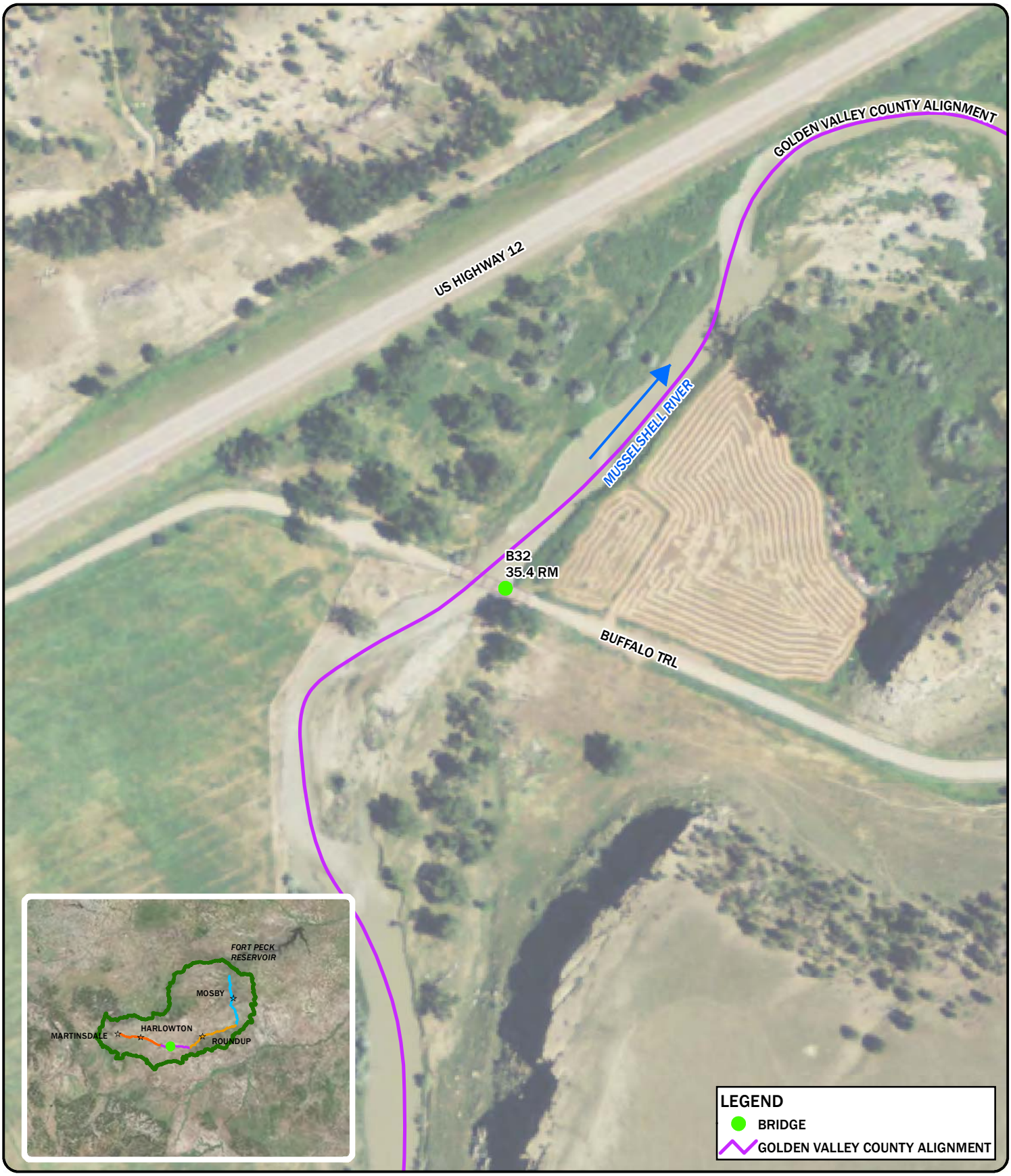
DATE: 11/2/2014

Path: P:\DNRC\Musselshell\GIS\Project\StructureInventory_Draft\B31-figure.mxd

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BI
	Date: 8/27/2014
	Description: Looking upstream at B31 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BJ
	Date: 8/27/2014
	Description: Looking upstream from B31 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BK
	Date: 8/27/2014
	Description: Looking downstream from B31 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1



DISPLAYED AS:
PROJ./ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/RATT/NRIS/NAIP 2013

0 100 200 400
Feet

FIGURE B32

PIONEER TECHNICAL SERVICES, INC.

MUSSELSHELL RIVER
STRUCTURE INVENTORY
B32

DATE: 11/2/2014

Path: P:\DNRC\Musselshell\GIS\Project\StructureInventory_Draft\B32-figure.mxd

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BL
	Date: 8/27/2014
	Description: Looking downstream from B32 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BM
	Date: 8/27/2014
	Description: Looking upstream from B32 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BN
	Date: 8/27/2014
	Description: Looking upstream at B32 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BO
	Date: 8/27/2014
	Description: Looking downstream at B32 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

DISPLAYED AS:
PROJ./ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/RATT/NRIS/NAIP 2013

0 100 200 400
Feet

FIGURE B33

PIONEER TECHNICAL SERVICES, INC.

MUSSELSHELL RIVER
STRUCTURE INVENTORY
B33

DATE: 11/2/2014

Path: P:\DNRC\Musselshell\GIS\Project\StructureInventory_Draft\B33-figure.mxd

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BP
	Date: 8/27/2014
	Description: Looking downstream at B33 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BQ
	Date: 8/27/2014
	Description: Looking upstream from B33 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BR
	Date: 8/27/2014
	Description: Looking downstream from B33 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BS
	Date: 8/27/2014
	Description: Looking upstream at B33 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

DISPLAYED AS:
PROJ./ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/RATT/NRIS/NAIP 2013

0 100 200 400
Feet

FIGURE B34

PIONEER TECHNICAL SERVICES, INC.

MUSSELSHELL RIVER
STRUCTURE INVENTORY
B34

DATE: 11/2/2014

Path: P:\DNRC\Musselshell\GIS\Project\StructureInventory_Draft\B34-figure.mxd

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BV
	Date: 8/27/2014
	Description: Looking upstream at B34 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BW
	Date: 8/27/2014
	Description: Looking upstream from B34 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BX
	Date: 8/27/2014
	Description: Looking downstream from B34 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BY
	Date: 8/27/2014
	Description: Looking downstream at B34 bridge structure
	Project: Musselshell River Floodplain Study - Phase 1

Golden Valley County
Musselshell River Diversion Structure Photographs
Mapping Activity Statement (MAS): No 2015-02

ID No.	River Reach	River Station	Material	Condition	Span (feet)	Pages
D13	2	21378	Concrete	Good	95	34, 35
D14	2	108680	Concrete	Good	120	36, 37
D15	2	127205	Concrete	Good	153	38, 39
D16	2	231144	Rock	Good	76	40, 41

DISPLAYED AS:
PROJ./ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/RATT/NRIS/NAIP 2013

0 100 200 400
Feet

FIGURE D13

PIONEER TECHNICAL SERVICES, INC.

MUSSELSHELL RIVER
STRUCTURE INVENTORY
D13

DATE: 11/2/2014

Path: P:\DNRC\Musselshell\GIS\Project\StructureInventory_Draft\D13-figure.mxd

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AC
	Date: 8/27/2014
	Description: Looking west at D13 diversion dam structure location
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AD
	Date: 8/27/2014
	Description: Looking west at D13 diversion dam structure location with reference rod
	Project: Musselshell River Floodplain Study - Phase 1

DISPLAYED AS:
PROJ./ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/RATT/NRIS/NAIP 2013

0 100 200 400
Feet

FIGURE D14

PIONEER TECHNICAL SERVICES, INC.

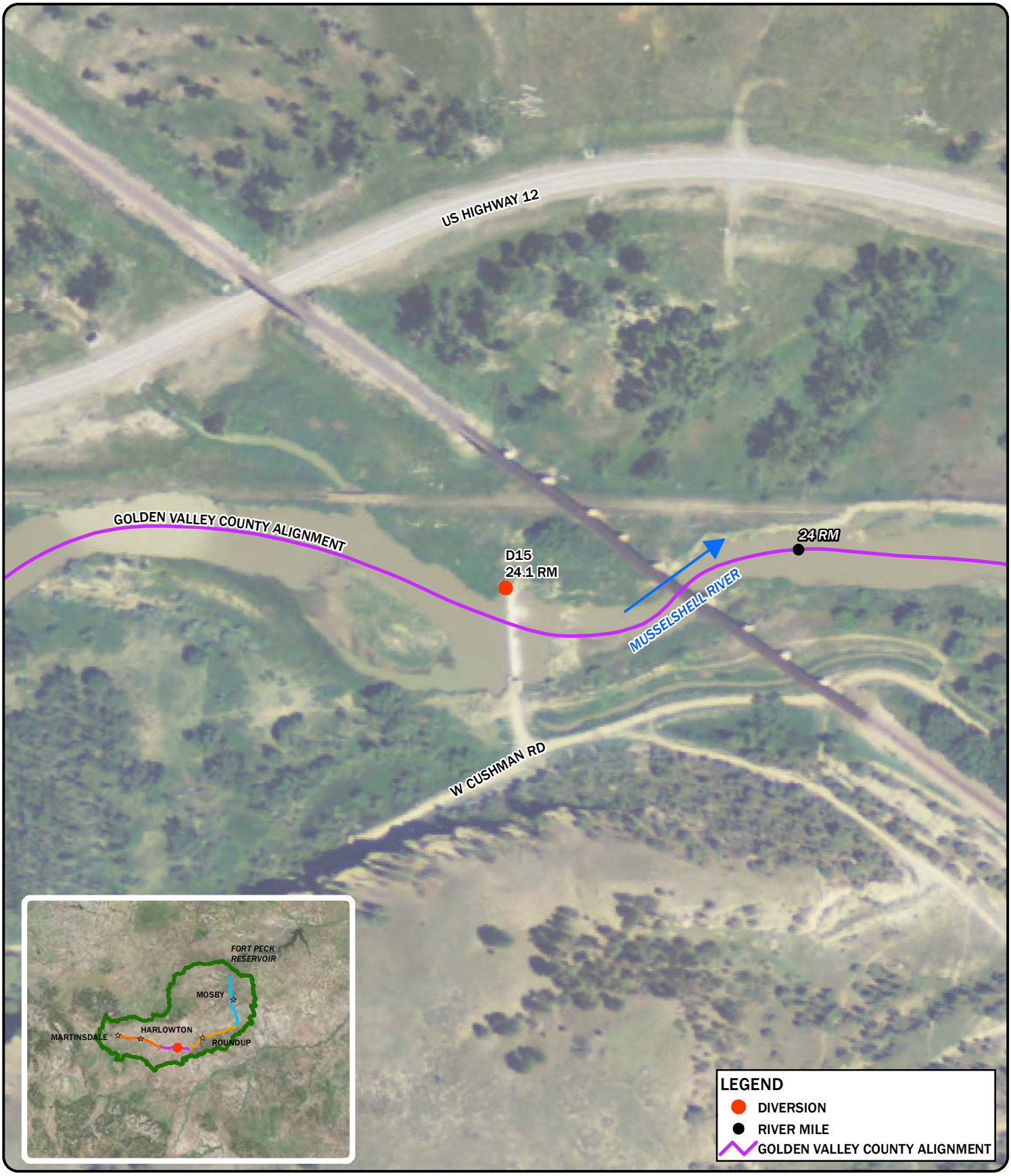
MUSSELSHELL RIVER
STRUCTURE INVENTORY
D14

DATE: 11/2/2014

Path: P:\DNRC\Musselshell\GIS\Project\StructureInventory_Draft\D14-figure.mxd

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AQ
	Date: 8/27/2014
	Description: Looking south at D14 diversion dam structure location
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827AR
	Date: 8/27/2014
	Description: Looking south at D14 diversion dam structure location with reference rod
	Project: Musselshell River Floodplain Study - Phase 1



DISPLAYED AS:
PROJ./ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/RATT/NRIS/NAIP 2013

0 100 200 400
Feet

FIGURE D15

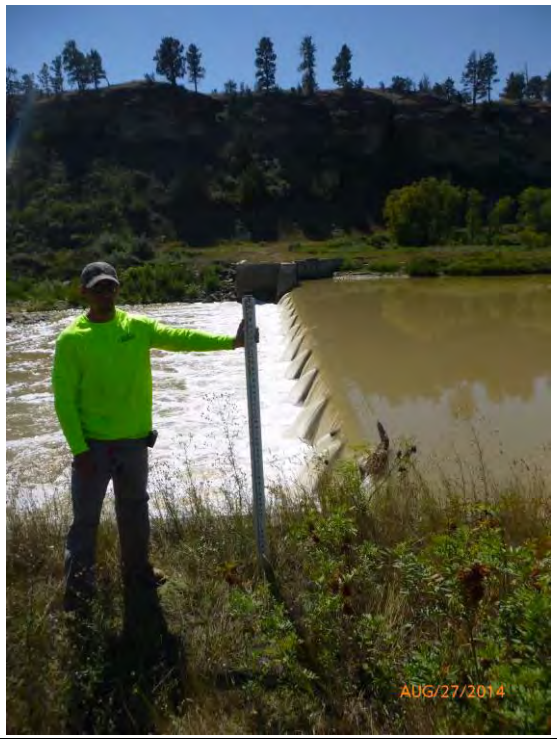
PIONEER TECHNICAL SERVICES, INC.

MUSSELSHELL RIVER
STRUCTURE INVENTORY
D15

DATE: 11/2/2014

Path: P:\DNRC\Musselshell\GIS\Project\StructureInventory_Draft\D15-figure.mxd

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BG
	Date: 8/27/2014
	Description: Looking south at D15 diversion dam structure location
	Project: Musselshell River Floodplain Study - Phase 1



PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BH
	Date: 8/27/2014
	Description: Looking south at D15 diversion dam structure location with reference rod
	Project: Musselshell River Floodplain Study - Phase 1

DISPLAYED AS:
PROJ./ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/RATT/NRIS/NAIP 2013

0 100 200 400
Feet

FIGURE D16

PIONEER TECHNICAL SERVICES, INC.

MUSSELSHELL RIVER
STRUCTURE INVENTORY
D16

DATE: 11/2/2014

Path: P:\DNRC\Musselshell\GIS\Project\StructureInventory_Draft\D16-figure.mxd

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BT
	Date: 8/27/2014
	Description: Looking south at D16 diversion dam location
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2014_0827BU
	Date: 8/27/2014
	Description: Looking south at D16 diversion dam location with reference rod
	Project: Musselshell River Floodplain Study - Phase 1

Appendix D – Floodway Data Tables

- Reach 7
- Reach 8

LOCATION		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH (**FEET**)	SECTION AREA (**SQ. FEET**)	MEAN VELOCITY (**FEET/ SEC**)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
MUSSELSHELL RIVER								
T	56,369	535	3135	4.1	3418.4	3418.4	3418.8	0.4
U	58,028	969	5508	2.4	3419.9	3419.9	3420.4	0.5
V	59,993	1135	4692	2.8	3420.8	3420.8	3421.3	0.5
W	61,520	428	2592	5.0	3422.2	3422.2	3422.6	0.4
X	62,859	1031	3716	3.5	3424.0	3424.0	3424.3	0.3
Y	64,745	1625	4731	2.7	3425.1	3425.1	3425.5	0.4
Z	66,409	2275[2]	5713	2.3	3427.6	3427.6	3427.6	0.0
AA	69,462	1144	3808	3.3	3429.2	3429.2	3429.3	0.1
AB	70,139	1645	4250	2.9	3430.0	3430.0	3430.1	0.1
AC	72,211	1682	6912	1.8	3431.1	3431.1	3431.5	0.4
AD	73,450	1287	7034	1.8	3434.1	3434.1	3434.2	0.1
AE	75,415	1372	5845	2.1	3434.6	3434.6	3434.7	0.1
AF	77,956	1479	6080	2.0	3435.3	3435.3	3435.6	0.3
AG	79,088	1414	5331	2.3	3435.9	3435.9	3436.3	0.4
AH	80,783	2132[2]	5608	2.2	3436.8	3436.8	3437.3	0.5
AI	82,573	2307	4473	2.8	3438.2	3438.2	3438.5	0.3
AJ	83,994	1788	4458	2.8	3439.3	3439.3	3439.7	0.4
AK	85,633	1145[2]	2975	4.2	3440.6	3440.6	3441.0	0.4
AL	86,790	1380	5398	2.3	3442.4	3442.4	3442.8	0.4

[1] Feet upstream of the eastern Golden Valley County Line
[2]Floodway topwidth includes width of high ground area

TABLE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

GOLDEN VALLEY COUNTY, MT

AND INCORPORATED AREAS

FLOODWAY DATA

MUSSELSHELL RIVER

LOCATION		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH (**FEET**)	SECTION AREA (**SQ. FEET**)	MEAN VELOCITY (**FEET/ SEC**)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
MUSSELSHELL RIVER								
CD	208,498	1941[2]	4891	2.6	3624.9	3624.9	3625.4	0.5
CE	210,147	586[2]	2935	3.4	3628.8	3628.8	3629.2	0.4
CF	211,630	1069	2312	4.4	3631.9	3631.9	3632.1	0.2
CG	213,205	666[2]	2675	4.0	3636.0	3636.0	3636.2	0.2
CH	214,946	771	2630	3.8	3639.9	3639.9	3640.2	0.3
CI	216,916	446	1796	5.6	3642.6	3642.6	3643.0	0.4
CJ	218,527	351	1664	6.1	3645.8	3645.8	3646.3	0.5
CK	220,120	485	2130	4.7	3649.6	3649.6	3649.9	0.3

[1] Feet upstream of the eastern Golden Valley County Line
[2]Floodway topwidth includes width of high ground area

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

GOLDEN VALLEY COUNTY, MT

AND INCORPORATED AREAS

FLOODWAY DATA

MUSSELSHELL RIVER

Appendix E – cHECk-RAS Checklists

- Reach 2
- Reach 7
- Reach 8

cHECk-RAS Report

HEC-RAS Project:	*musselshell_reach_2a.prj*
Plan File:	*musselshell_reach_2a.p01*
Geometry File:	*musselshell_reach_2a.g01*
Flow File:	*musselshell_reach_2a.f01*
Report Date:	*4/4/2016*

Message ID	Message	Cross sections affected	Comments
BR LF 01	This is ($strucname$). The selected profile is $profilename$. Type of flow is low flow because, 1. EGEL 3 of $egel3$ is less than or equal to MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is less than MxLoCdU of $mxlocdu$.	4750(Bridge-UP); 34266(Bridge-UP)	No Action - This is a statement not an error.
BR LW 01	This is a Bridge Section. The selected profile is $profilename$. Type of flow is low and weir flow because, 1. EGEL 3 of $egel3$ is greater than MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is less than MxLoCdU of $mxlocdu$.	4750(Bridge-UP); 34266(Bridge-UP)	No Action - This is a statement not an error.
BR PW 01	This is a Bridge Section. The selected profile is $profilename$. Type of flow is sluice gate pressure and weir flow because, 1. EGEL 3 of $egel3$ is greater than MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is equal to or greater than MxLoCdU of $mxlocdu$. 3. WSEL 2 of $wsel2$ is less than MxLoCdD of $mxlocdd$.	4750(Bridge-UP); 34266(Bridge-UP)	No Action - This is a statement not an error.
BR PW 02	This is a Bridge Section. The selected profile is $profilename$. Type of flow is submerged pressure and weir flow because, 1. EGEL 3 of $egel3$ is greater than MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is equal to or greater than MxLoCdU of $mxlocdu$. 3. WSEL 2 of $wsel2$ is equal to or greater than MxLoCdD of $mxlocdd$.	4750(Bridge-UP)	No Action - This is a statement not an error.
BR PW 06	This is $strucname$. The selected profile is $profilename$. EGEL of $egel3$ at Section 3 is higher than the MinTopRd of $minelweirflow$. However the WSEL of $wsel$ at BRU is less than MinTopRd. Please investigate the problem.	34266(Bridge-UP)	No Action - WSEL is less due to topographic grades.
MP SW 01DK	The name of the stream is ($streamname$). The flow regime is subcritical or mixed flow. Starting water-surface elevations are computed from Known WSELs as the downstream boundary condition. Provide backup information on Known water-surface elevations or use same energy slope for all the profiles as the starting boundary condition and rerun the plan.	MPCHECK	No Action - SWSE is from downstream model reach.

NT RC 05	The left overbank n-value of $nlob$ and the right overbank n-value of $nrob$ are less than or equal to the channel n-value of nch. Follow the procedure in (FHWA, 1984) to compute the n-value for the natural floodplain and the channel. Or follow the procedure in (USGS, 1977) to compute the n-value for urban development. Please submit supporting information on the evaluation of n-values.	-1383	No Action - Higher channel n-value is necessary for subcritical flow condition.
ST GD 02BD	This is the Downstream Bridge Section. There is only one bridge. However, the low cord line crosses the ground line at more than two locations. The ground and deck/roadway data should be checked.	4750(Bridge); 34266(Bridge)	No Action - Structure is appropriately modeled.
ST GD 02BU	This is the Upstream Bridge Section. There is only one bridge. However, the low cord line crosses the ground line at more than two locations. The ground and deck/roadway data should be checked.	4750(Bridge); 34266(Bridge)	No Action - Structure is appropriately modeled.
ST GD 03S3	This is Section 3. The highest flood frequency that has weir flow is $profilename$. All the ineffective flow elevations at Section 3 are lower than the water-surface elevation at Section 3. The velocity head at Section 3 is more than 0.5 foot and more than the velocity head at Section 4. Section 3 should be checked to make sure it represents the natural valley cross section. The HEC-RAS geometry file may need to be recreated using a GIS program.	4750(Bridge)	No Action - Structure is appropriately modeled.
ST IF 04S3R	This is Section 3. The selected profile is $profilename$. Weir flow occurs at ($strucname$). However, the right ineffective flow elevation of $ineffell$ at the right ineffective flow station $ineffstar$ is equal to or higher than the WSEL of $wsel3$. The computed upstream RMnTpRd is $rmntprdu$. The ineffective flow elevation should be equal to the computed RMnTpRdU.	4779(Bridge)	No Action - Structure is appropriately modeled.
ST IF 07S1R	This is Section 1. Right Ineffective flow option was considered at this section. However, it should be a fully expanded cross section. Ineffective flow stations and elevations should be cleared from this section, unless the areas beyond the ineffective flow stations are not within the flow path of the stream. This message should be ignored if this section is Section 3 of the downstream structure.	33890(Bridge)	No Action - Ineffective flow option for area not within flow path.

ST IF 07S4R	This is Section 4. Right Ineffective flow option was considered at this section. However, it should be a fully expanded cross section. Ineffective flow stations and elevations should be cleared from this section, unless the areas beyond the ineffective flow stations are not within the flow path of the stream. This message should be ignored if this section is Section 2 of the upstream structure.	34500(Bridge)	No Action - Ineffective flow option for area not within flow path.
ST IF 09S3L	This is Section 3. The highest flood frequency that is having low flow or pressure flow is $profilename$. The left ineffective flow elevation, Ineff_El_Left, should be equal to or higher than the WSEL at Section 3. However, the Ineff_El_Left of $ineffell$ at the left ineffective flow station $ineffstal$ is lower than the WSEL of $wsel3$ at Section 3. The computed Left Upstream Minimum Top Road elevation, LMnTpRdU of $lmntprdu$ is higher than the WSEL of $wsel3$ at Section 3. The Ineff_El_Left should be raised to the computed LMnTpRdU.	34316(Bridge)	No Action - Structure is appropriately modeled.
ST IF 10S2R	This is Section 2 of a ($Structure$). More than one set of Right Ineffective Flow Stations were considered. There is only one structure at this location. Multiple Block Ineffective Flow option should not be used unless the area blocked by the ineffective flow stations can be considered non conveyance. cHECk-RAS will only check the ineffective flow elevations adjacent to the structure opening.	34244(Bridge)	No Action - Multiple Block Ineffective is for non-conveyance.
ST IF 10S3R	This is Section 3 of a ($Structure$). More than one set of Left Ineffective Flow Stations were considered. There is only one structure at this location. Multiple Block Ineffective Flow option should not be used unless the area blocked by the ineffective flow stations can be considered non conveyance. cHECk-RAS will only check the ineffective flow elevations adjacent to the structure opening.	4779(Bridge); 34316(Bridge)	No Action - Multiple Block Ineffective is for non-conveyance.
XS DC 01	Discharge decreases in the downstream direction for $assignedname$ flood. There are no lateral structures. Documentation of hydrologic analysis is required or provide explanation.	9703	No Action - Discharge decrease in downstream direction is consistent with Hydrologic Analysis Report.

XS DF 01L	Divided flow. Flow code will be DL. The $assignedname$ flood discharge has a divided flow. The starting and ending stations of the cross section should not extend beyond the watershed boundary of the studied stream. Please review the extent of the cross section. If the cross section extends beyond the watershed boundary then the cross sections need to be trimmed and the HEC-RAS geometry file may need to be recreated using a GIS program. Or use the ineffective flow option, if it has not been considered, to limit the extent of the cross section or to block the divided flow area if it is a local depression.	9703; 31127	No Action - Cross section is appropriatley modeled.
XS DF 01R	Divided flow. Flow code will be DR. The $assignedname$ flood discharge has a divided flow. The starting and ending stations of the cross section should not extend beyond the watershed boundary of the studied stream. Please review the extent of the cross section. If the cross section extends beyond the watershed boundary then the cross section needs to be trimmed and the HEC-RAS geometry file may need to be recreated using a GIS program. Or use the ineffective flow option, if it has not been considered, to limit the extent of the cross section or to block the divided flow area if it is a local depression.	1820; 20052; 28570	No Action - Cross section is appropriatley modeled.
XS DT 02R	The Right overbank distance of rob is greater than the channel distance of chl by more than two times. The Right overbank distance may be in error. Please review the creation of left overbank, channel and right overbank distances. The HEC-RAS geometry file may need to be recreated using a GIS program. Please resolve the differences between the distances.	34266(Bridge-DN); 34316	No Action - Multiple Block Right overbank distance is correct.
XS IF 01L	Flow code will be IL. The area left of the ineffective flow station may be considered effective. The $assignedname$ WSEL of $wsel$ is higher than the ground elevation $grelv$ of the Left Ineffective Flow Station. However, it is equal to or lower than the left ineffective flow elevation of $ineffell$. The lateral structure was not modeled downstream of this River Station. Lower the ineffective flow elevation to the ground elevation to consider the area left of the ineffective flow station as effective, or model a lateral structure if the overflow will take a different flow path. The ineffective flow elevation could be accepted if the area left of the ineffective flow station is non conveyance.	15137; 48024	No Action - Ineffective flow option for area not within flow path.

XS IF 02L	Flow code will be MIL. Multiple (block) Ineffective Stations are selected for the left overbank at this River Station. This is not Section 2 or Section 3 of Multiple Openings or Multiple Culverts. Please explain why the multiple blocks ineffective flow option was used. Consider using the normal ineffective flow option.	4779; 6835; 8729; 10440; 20052; 28570; 34244; 34316; 36937; 38062; 45615; 49088	No Action - Multiple Block block ineffective is required for differing flow path conditions.
XS IF 02R	Flow code will be MIR. Multiple (block) Ineffective Stations are selected for the right overbank at this River Station. This is not Section 2 or Section 3 of Multiple Openings or Multiple Culverts. Please justify why the Multiple Blocks Ineffective Flow option was used. Consider using the normal Ineffective Flow option.	0; 30139; 37475	No Action - Multiple block ineffective is required for differring flow path conditions.
XS SP 01	Additional cross sections may need to be added between River Station Up of $secnoup$ and River Station Dn of $secnodn$ because all of the following conditions are met for the 1%-annual-chance flood. 1.Change in HV > 0.5; 2.Conv_Ratio < 0.7 or Conv_Ratio > 1.4 ; 3.DEPTH Ratio < 0.9 or DEPTH Ratio > 1.1; 4.TOPWID Ratio < 0.5 or TOPWID Ratio > 2.0; 5.Length Chnl Up / 500 > 1.1. The HEC-RAS geometry file may need to be recreated using a GIS program.	1820	No Action-Cross section spacing meets modeling guidelines.

cHECk-RAS Report

HEC-RAS Project:	*musselshell_reach_2b.prj*
Plan File:	*musselshell_reach_2b.p01*
Geometry File:	*musselshell_reach_2b.g01*
Flow File:	*musselshell_reach_2b.f01*
Report Date:	*4/6/2016*

Message ID	Message	Cross sections affected	Comments
BR LF 01	This is ($strucname$). The selected profile is $profilename$. Type of flow is low flow because, 1. EGEL 3 of $egel3$ is less than or equal to MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is less than MxLoCdU of $mxlocdu$.	119394(Bridge-UP); 177997(Bridge-UP); 187234(Bridge-UP)	No Action - This is a statement not an error.
BR LW 01	This is a Bridge Section. The selected profile is $profilename$. Type of flow is low and weir flow because, 1. EGEL 3 of $egel3$ is greater than MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is less than MxLoCdU of $mxlocdu$.	177997(Bridge-UP); 187234(Bridge-UP)	No Action - This is a statement not an error.
BR PW 01	This is a Bridge Section. The selected profile is $profilename$. Type of flow is sluice gate pressure and weir flow because, 1. EGEL 3 of $egel3$ is greater than MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is equal to or greater than MxLoCdU of $mxlocdu$. 3. WSEL 2 of $wsel2$ is less than MxLoCdD of $mxlocdd$.	119394(Bridge-UP); 177997(Bridge-UP); 187234(Bridge-UP)	No Action - This is a statement not an error.
BR PW 02	This is a Bridge Section. The selected profile is $profilename$. Type of flow is submerged pressure and weir flow because, 1. EGEL 3 of $egel3$ is greater than MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is equal to or greater than MxLoCdU of $mxlocdu$. 3. WSEL 2 of $wsel2$ is equal to or greater than MxLoCdD of $mxlocdd$.	119394(Bridge-UP); 177997(Bridge-UP); 187234(Bridge-UP)	No Action - This is a statement not an error.
BR PW 06	This is $strucname$. The selected profile is $profilename$. EGEL of $egel3$ at Section 3 is higher than the MinTopRd of $minelweirflow$. However the WSEL of $wsel$ at BRU is less than MinTopRd. Please investigate the problem.	187234(Bridge-UP)	No Action - Roadway is overtopped at the 10% AC.
MP SW 01DK	The name of the stream is ($streamname$). The flow regime is subcritical or mixed flow. Starting water-surface elevations are computed from Known WSELs as the downstream boundary condition. Provide backup information on Known water-surface elevations or use same energy slope for all the profiles as the starting boundary condition and rerun the plan.	MPCHECK	No Action - SWSE is from downstream model reach.

NT RC 05	The left overbank n-value of $nlob$ and the right overbank n-value of $nrob$ are less than or equal to the channel n-value of nch. Follow the procedure in (FHWA, 1984) to compute the n-value for the natural floodplain and the channel. Or follow the procedure in (USGS, 1977) to compute the n-value for urban development. Please submit supporting information on the evaluation of n-values.	172426; 173565	No Action - Channel n-value is higher to correct critical depth
NT TL 02	Contraction and expansion loss coefficients are cc and ce, respectively. However, this cross section is not at a hydraulic structure. They should be equal to 0.1 and 0.3 according to page 5-8 of the HEC-RAS Hydraulic Reference Manual (HEC, 2010).	126669; 126692; 126736; 126786; 126856; 126901; 126952; 126995; 127059; 127134; 127205; 127287; 157551; 157611; 157739	No Action - Contraction and expansion loss coefficients set for hydraulic sturcture with independent cross sections.
ST GD 02BD	This is the Downstream Bridge Section. There is only one bridge. However, the low cord line crosses the ground line at more than two locations. The ground and deck/roadway data should be checked.	119394(Bridge); 177997(Bridge); 187234(Bridge)	No Action - Structure is appropriately modeled..
ST GD 02BU	This is the Upstream Bridge Section. There is only one bridge. However, the low cord line crosses the ground line at more than two locations. The ground and deck/roadway data should be checked.	119394(Bridge); 177997(Bridge); 187234(Bridge)	No Action - Structure is appropriately modeled..
ST GD 03S3	This is Section 3. The highest flood frequency that has weir flow is $profilename$. All the ineffective flow elevations at Section 3 are lower than the water-surface elevation at Section 3. The velocity head at Section 3 is more than 0.5 foot and more than the velocity head at Section 4. Section 3 should be checked to make sure it represents the natural valley cross section. The HEC-RAS geometry file may need to be recreated using a GIS program.	177997(Bridge); 187234(Bridge)	No Action - Structure is appropriately modeled..
ST IF 03S3L	This is Section 3. The selected profile is $profilename$. Weir flow occurs at ($strucname$). However, the left ineffective flow elevation of $ineffelr$ at the left ineffective flow station $ineffstal$ is equal to or higher than the WSEL of $wsel3$. The computed upstream LMnTpRd is $lmntprdu$. The ineffective flow elevation should be equal to or lower than the computed LMnTpRdU. It should also be lower than the WSEL at Section 3.	178040(Bridge); 187272(Bridge)	No Action - Structure is appropriately modeled..

ST IF 04S3R	This is Section 3. The selected profile is $profilename$. Weir flow occurs at ($strucname$). However, the right ineffective flow elevation of $ineffell$ at the right ineffective flow station $ineffstar$ is equal to or higher than the WSEL of $wsel3$. The computed upstream RMnTpRd is $rmntprdu$. The ineffective flow elevation should be equal to the computed RMnTpRdU.	178040(Bridge); 187272(Bridge)	No Action - Structure is appropriately modeled..
ST IF 05S2L	This is Section 2 of a hydraulic structure. The left ineffective flow station is within the opening area of the structure. The left ineffective flow station of $ineffstal$ is greater than the downstream left abutment station of $abutstal$ at ($strucname$). The Left ineffective flow station should be adjusted.	187211(Bridge)	No Action - Structure is appropriately modeled..
ST IF 05S2R	This is Section 2 of a hydraulic structure. The right ineffective flow station is within the opening area of the structure. The right ineffective flow station of $ineffstar$ is less than the upstream right abutment station of $abutstar$ at ($strucname$). The Right ineffective flow station should be adjusted.	187211(Bridge)	No Action - Structure is appropriately modeled..
ST IF 05S3L	This is Section 3 of a hydraulic structure. The left ineffective flow station is within the opening area of the structure. The left ineffective flow station of $ineffstal$ is greater than the upstream left abutment station of $abutstal$ at ($strucname$). The Left ineffective flow station should be adjusted.	187272(Bridge)	No Action - Structure is appropriately modeled..
ST IF 07S1L	This is Section 1. Left Ineffective flow option was considered at this section. However, it should be a fully expanded cross section. Ineffective flow stations and elevations should be cleared from this section, unless the areas beyond the ineffective flow stations are not within the flow path of the stream. This message should be ignored if this section is Section 3 of the downstream structure.	119150(Bridge); 187016(Bridge)	No Action - Structure is appropriately modeled..
ST IF 07S1R	This is Section 1. Right Ineffective flow option was considered at this section. However, it should be a fully expanded cross section. Ineffective flow stations and elevations should be cleared from this section, unless the areas beyond the ineffective flow stations are not within the flow path of the stream. This message should be ignored if this section is Section 3 of the downstream structure.	119150(Bridge); 187016(Bridge)	No Action - Structure is appropriately modeled..

ST IF 07S4L	This is Section 4. Left Ineffective flow option was considered at this section. However, it should be a fully expanded cross section. Ineffective flow stations and elevations should be cleared from this section, unless the areas beyond the ineffective flow stations are not within the flow path of the stream. This message should be ignored if this section is Section 2 of the upstream structure.	119567(Bridge); 187390(Bridge)	No Action - Structure is appropriately modeled..
ST IF 07S4R	This is Section 4. Right Ineffective flow option was considered at this section. However, it should be a fully expanded cross section. Ineffective flow stations and elevations should be cleared from this section, unless the areas beyond the ineffective flow stations are not within the flow path of the stream. This message should be ignored if this section is Section 2 of the upstream structure.	119567(Bridge); 187390(Bridge)	No Action - Structure is appropriately modeled..
ST IF 10S2R	This is Section 2 of a ($Structure$). More than one set of Right Ineffective Flow Stations were considered. There is only one structure at this location. Multiple Block Ineffective Flow option should not be used unless the area blocked by the ineffective flow stations can be considered non conveyance. cHECk-RAS will only check the ineffective flow elevations adjacent to the structure opening.	187211(Bridge)	No Action - Structure is appropriately modeled..
ST IF 10S3R	This is Section 3 of a ($Structure$). More than one set of Left Ineffective Flow Stations were considered. There is only one structure at this location. Multiple Block Ineffective Flow option should not be used unless the area blocked by the ineffective flow stations can be considered non conveyance. cHECk-RAS will only check the ineffective flow elevations adjacent to the structure opening.	187272(Bridge)	No Action - Structure is appropriately modeled..
XS BO 01R	Block Obstruction. Flow Code will be "BR". The block obstruction elevation is higher than the right bank elevation. Lower the block obstruction elevation to the bank elevation or provide an explanation. This option is suitable to fill isolated depression areas.	126901	No Action - Blocked obstruction is to model pier skew.

XS DF 01L	Divided flow. Flow code will be DL. The $assignedname$ flood discharge has a divided flow. The starting and ending stations of the cross section should not extend beyond the watershed boundary of the studied stream. Please review the extent of the cross section. If the cross section extends beyond the watershed boundary then the cross sections need to be trimmed and the HEC-RAS geometry file may need to be recreated using a GIS program. Or use the ineffective flow option, if it has not been considered, to limit the extent of the cross section or to block the divided flow area if it is a local depression.	87270; 119363; 119428; 167985; 178040; 207615	No Action - Cross section is appropriately modeled.
XS DF 01R	Divided flow. Flow code will be DR. The $assignedname$ flood discharge has a divided flow. The starting and ending stations of the cross section should not extend beyond the watershed boundary of the studied stream. Please review the extent of the cross section. If the cross section extends beyond the watershed boundary then the cross section needs to be trimmed and the HEC-RAS geometry file may need to be recreated using a GIS program. Or use the ineffective flow option, if it has not been considered, to limit the extent of the cross section or to block the divided flow area if it is a local depression.	87270; 87932; 98255; 99236; 102225; 123287; 144485; 205547	No Action - Cross section is appropriately modeled.
XS IF 01L	Flow code will be IL. The area left of the ineffective flow station may be considered effective. The $assignedname$ WSEL of $wsel$ is higher than the ground elevation $grelv$ of the Left Ineffective Flow Station. However, it is equal to or lower than the left ineffective flow elevation of $ineffell$. The lateral structure was not modeled downstream of this River Station. Lower the ineffective flow elevation to the ground elevation to consider the area left of the ineffective flow station as effective, or model a lateral structure if the overflow will take a different flow path. The ineffective flow elevation could be accepted if the area left of the ineffective flow station is non conveyance.	157551; 157611; 157739	No Action - Cross section is appropriately modeled.

XS IF 01R	Flow code will be IR. The area to the right of the ineffective flow station may be considered effective. The $assignedname$ WSEL of $wsel$ is higher than the ground elevation $grelv$ of the Right Ineffective Flow Station. However, it is equal to or lower than the right ineffective flow elevation of $ineffelr$. The lateral structure was not modeled downstream of this River Station. Lower the ineffective flow elevation to the ground elevation to consider the area right of the ineffective flow station as effective, or model a lateral structure if the overflow will take a different flow path. The ineffective flow elevation could be accepted if the area right of the ineffective flow station is non conveyance.	157551; 168283; 168351; 168494	No Action - Cross section is appropriately modeled.
XS IF 02L	Flow code will be MIL. Multiple (block) Ineffective Stations are selected for the left overbank at this River Station. This is not Section 2 or Section 3 of Multiple Openings or Multiple Culverts. Please explain why the multiple blocks ineffective flow option was used. Consider using the normal ineffective flow option.	85096; 85633; 86263; 86790; 95526; 96416; 98255; 103111; 104165; 106294; 107283; 117224; 118134; 119150; 119567; 121473; 125088; 126105; 126669; 126692; 126736; 126786; 126856; 126901; 126952; 126995; 127059; 127134; 127205; 127287; 127505; 127532; 127555; 127583; 128640; 129609; 131654; 132523; 133080; 133763; 138125; 138817; 139424; 140456; 140983; 141634; 142745; 146439; 147411; 148248; 163871; 164897; 165276; 185527; 187211; 187272; 187390; 203653; 205547; 207615; 208027; 208498	No Action - Multiple block ineffective is required for differing flow path condtions.
XS IF 02R	Flow code will be MIR. Multiple (block) Ineffective Stations are selected for the right overbank at this River Station. This is not Section 2 or Section 3 of Multiple Openings or Multiple Culverts. Please justify why the Multiple Blocks Ineffective Flow option was used. Consider using the normal Ineffective Flow option.	86790; 99236; 100800; 106294; 107283; 118134; 121473; 122527; 123287; 126736; 126786; 126952; 154496; 155372; 156388; 157312; 169863; 171160; 200812	No Action - Multiple block ineffective is required for differing flow path condtions.
XS LC 01	LenChl Up/TopWdthAct Dn = $ratioVal$. The ratio is more than 1.1. LenChlUp is more than 500 feet. This cross section is located too far upstream from the critical depth cross section $secnocritical$ for the $Assigned_Name$ flood. The cross section should move closer to the critical depth section, or an additional cross section should be added between the two cross sections. The HEC-RAS geometry file may need to be recreated using a GIS program.	109742; 173565; 180749	No Action - Cross section placement based on channel meander aligment.

cHECk-RAS Report

HEC-RAS Project:	*musselshell_reach_2c.prj*
Plan File:	*musselshell_reach_2c.p01*
Geometry File:	*musselshell_reach_2c.g01*
Flow File:	*musselshell_reach_2c.f01*
Report Date:	*4/26/2016*

Message ID	Message	Cross sections affected	Comments
BR LW 01	This is a Bridge Section. The selected profile is $profilename$. Type of flow is low and weir flow because, 1. EGEL 3 of $egel3$ is greater than MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is less than MxLoCdU of $mxlocdu$.	265062(Bridge-UP)	No Action - This is a statement and not an error.
MP SW 01DK	The name of the stream is ($streamname$). The flow regime is subcritical or mixed flow. Starting water-surface elevations are computed from Known WSELs as the downstream boundary condition. Provide backup information on Known water-surface elevations or use same energy slope for all the profiles as the starting boundary condition and rerun the plan.	MPCHECK	No Action - SWSE is from downstream model reach.
ST GD 02BD	This is the Downstream Bridge Section. There is only one bridge. However, the low cord line crosses the ground line at more than two locations. The ground and deck/roadway data should be checked.	265062(Bridge)	No Action - Structure is appropriately modeled.
ST GD 02BU	This is the Upstream Bridge Section. There is only one bridge. However, the low cord line crosses the ground line at more than two locations. The ground and deck/roadway data should be checked.	265062(Bridge)	No Action - Structure is appropriately modeled.
ST IF 04S3R	This is Section 3. The selected profile is $profilename$. Weir flow occurs at ($strucname$). However, the right ineffective flow elevation of $ineffell$ at the right ineffective flow station $ineffstar$ is equal to or higher than the WSEL of $wsel3$. The computed upstream RMnTpRd is $rmntprdu$. The ineffective flow elevation should be equal to the computed RMnTpRdU.	265099(Bridge)	No Action - Ineffective flow elevation is set at RMnTpRdu.
ST IF 07S1L	This is Section 1. Left Ineffective flow option was considered at this section. However, it should be a fully expanded cross section. Ineffective flow stations and elevations should be cleared from this section, unless the areas beyond the ineffective flow stations are not within the flow path of the stream. This message should be ignored if this section is Section 3 of the downstream structure.	264821(Bridge)	No Action - Ineffective flow option for area not within flow path.

ST IF 07S4L	This is Section 4. Left Ineffective flow option was considered at this section. However, it should be a fully expanded cross section. Ineffective flow stations and elevations should be cleared from this section, unless the areas beyond the ineffective flow stations are not within the flow path of the stream. This message should be ignored if this section is Section 2 of the upstream structure.	265206(Bridge)	No Action - Ineffective flow option for area not within flow path.
XS DF 01L	Divided flow. Flow code will be DL. The $assignedname$ flood discharge has a divided flow. The starting and ending stations of the cross section should not extend beyond the watershed boundary of the studied stream. Please review the extent of the cross section. If the cross section extends beyond the watershed boundary then the cross sections need to be trimmed and the HEC-RAS geometry file may need to be recreated using a GIS program. Or use the ineffective flow option, if it has not been considered, to limit the extent of the cross section or to block the divided flow area if it is a local depression.	264821; 265024; 265099	No Action - Higher Mannings n to reduce conveyance in divided flow.
XS DF 01R	Divided flow. Flow code will be DR. The $assignedname$ flood discharge has a divided flow. The starting and ending stations of the cross section should not extend beyond the watershed boundary of the studied stream. Please review the extent of the cross section. If the cross section extends beyond the watershed boundary then the cross section needs to be trimmed and the HEC-RAS geometry file may need to be recreated using a GIS program. Or use the ineffective flow option, if it has not been considered, to limit the extent of the cross section or to block the divided flow area if it is a local depression.	233044	No Action - Higher Mannings n to reduce conveyance in divided flow.
XS IF 02L	Flow code will be MIL. Multiple (block) Ineffective Stations are selected for the left overbank at this River Station. This is not Section 2 or Section 3 of Multiple Openings or Multiple Culverts. Please explain why the multiple blocks ineffective flow option was used. Consider using the normal ineffective flow option.	221491; 223222; 224746; 225514; 226536; 233044; 233788; 235271; 267444; 267903	No Action - Multiple block ineffective is required for differing flow path.

cHECk-RAS Report

HEC-RAS Project:	*musselshell_reach7.prj*
Plan File:	*musselshell_reach7.p03*
Geometry File:	*musselshell_reach7.g03*
Flow File:	*musselshell_reach7.f01*
Report Date:	*4/5/2016*

Message ID	Message	Cross sections affected	Comments
BR LF 01	This is ($strucname$). The selected profile is $profilename$. Type of flow is low flow because, 1. EGEL 3 of $egel3$ is less than or equal to MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is less than MxLoCdU of $mxlocdu$.	72493(Bridge-UP)	No Action - This is a statement not an error.
BR PF 01	This is a Bridge Section. The selected profile is $profilename$. Type of flow is sluice gate pressure flow because, 1. EGEL 3 of $egel3$ is less than or equal to MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is greater than or equal to MxLoCdU of $mxlocdu$. 3. WSEL 2 of $wsel2$ is less than MxLoCdD of $mxlocdd$.	72493(Bridge-UP)	No Action - This is a statement not an error.
BR PW 01	This is a Bridge Section. The selected profile is $profilename$. Type of flow is sluice gate pressure and weir flow because, 1. EGEL 3 of $egel3$ is greater than MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is equal to or greater than MxLoCdU of $mxlocdu$. 3. WSEL 2 of $wsel2$ is less than MxLoCdD of $mxlocdd$.	72493(Bridge-UP)	No Action - This is a statement not an error.
MP SW 01DK	The name of the stream is ($streamname$). The flow regime is subcritical or mixed flow. Starting water-surface elevations are computed from Known WSELs as the downstream boundary condition. Provide backup information on Known water-surface elevations or use same energy slope for all the profiles as the starting boundary condition and rerun the plan.	MPCHECK	No Action - SWSE is from downstream model reach.
ST GD 02BD	This is the Downstream Bridge Section. There is only one bridge. However, the low cord line crosses the ground line at more than two locations. The ground and deck/roadway data should be checked.	72493(Bridge)	No Action - Structure is appropriately modeled.
ST GD 02BU	This is the Upstream Bridge Section. There is only one bridge. However, the low cord line crosses the ground line at more than two locations. The ground and deck/roadway data should be checked.	72493(Bridge)	No Action - Structure is appropriately modeled.

XS DF 01L	Divided flow. Flow code will be DL. The $assignedname$ flood discharge has a divided flow. The starting and ending stations of the cross section should not extend beyond the watershed boundary of the studied stream. Please review the extent of the cross section. If the cross section extends beyond the watershed boundary then the cross sections need to be trimmed and the HEC-RAS geometry file may need to be recreated using a GIS program. Or use the ineffective flow option, if it has not been considered, to limit the extent of the cross section or to block the divided flow area if it is a local depression.	72452; 72548; 73450	No Action - Cross section is appropriately modeled.
XS DF 01R	Divided flow. Flow code will be DR. The $assignedname$ flood discharge has a divided flow. The starting and ending stations of the cross section should not extend beyond the watershed boundary of the studied stream. Please review the extent of the cross section. If the cross section extends beyond the watershed boundary then the cross section needs to be trimmed and the HEC-RAS geometry file may need to be recreated using a GIS program. Or use the ineffective flow option, if it has not been considered, to limit the extent of the cross section or to block the divided flow area if it is a local depression.	87270	No Action - Cross section is appropriately modeled.
XS IF 02L	Flow code will be MIL. Multiple (block) Ineffective Stations are selected for the left overbank at this River Station. This is not Section 2 or Section 3 of Multiple Openings or Multiple Culverts. Please explain why the multiple blocks ineffective flow option was used. Consider using the normal ineffective flow option.	56885; 57395; 58795; 64191; 64745; 65297; 65868; 69462; 70139; 82573; 85096; 85633; 86263; 86790	No Action - Multiple block ineffective is required for differing flow path conditions.
XS IF 02R	Flow code will be MIR. Multiple (block) Ineffective Stations are selected for the right overbank at this River Station. This is not Section 2 or Section 3 of Multiple Openings or Multiple Culverts. Please justify why the Multiple Blocks Ineffective Flow option was used. Consider using the normal Ineffective Flow option.	86790	No Action - Multiple block ineffective is required for differing flow path conditions.

XS SP 01	Additional cross sections may need to be added between River Station Up of $secnoup$ and River Station Dn of $secnodn$ because all of the following conditions are met for the 1%-annual-chance flood. 1.Change in HV > 0.5; 2.Conv_Ratio < 0.7 or Conv_Ratio > 1.4 ; 3.DEPTH Ratio < 0.9 or DEPTH Ratio > 1.1; 4.TOPWID Ratio < 0.5 or TOPWID Ratio > 2.0; 5.Length Chnl Up / 500 > 1.1. The HEC-RAS geometry file may need to be recreated using a GIS program.	64745	No Action - Cross section spacing meets modeling guidelines.

cHECk-RAS Report

HEC-RAS Project:	*musselshell_reach7.prj*
Plan File:	*musselshell_reach7.p01*
Geometry File:	*musselshell_reach7.g03*
Flow File:	*musselshell_reach7.f02*
Report Date:	*4/5/2016*

Message ID	Message	Cross sections affected	Comments
BR PF 01	This is a Bridge Section. The selected profile is $profilename$. Type of flow is sluice gate pressure flow because, 1. EGEL 3 of $egel3$ is less than or equal to MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is greater than or equal to MxLoCdU of $mxlocdu$. 3. WSEL 2 of $wsel2$ is less than MxLoCdD of $mxlocdd$.	72493(Bridge-UP)	No Action - This is a statement not an error.
BR PF 04	This is a Bridge Section. Input BrSelMthd is Press/Weir. The highest flood frequency profile is $profilename$. Type of flow is sluice gate pressure flow only. However, the highest flood frequency CritWS of $critws$at BR U is less than or equal to the WSEL of $wsel$ at BR U. Energy should be selected as the High Flow Method.	72493(Bridge-UP)	No Action - This is a statement not an error.
FW SW 01M1	The name of the stream is ($streamname$). Encroachment Method 1 is used. Known WS option is used for both the 1%-annual-chance flood and floodway profiles. The floodway profile starting WSEL of $knownwsfw$ is not equal to the 1%-annual-chance flood starting WSEL of $knownws100yr$ plus the allowable surcharge value of $allowsurchrg$. The Normal Depth option with the energy slope of the 1%-annual-chance flood should be used for both profiles and the plan should be rerun. This message may not be applicable when revising only a portion of a hydraulic model.	51604	No Action - Know SWSE is the from downstream model reach.
FW SW 04M1	The name of the stream is ($streamname$). Encroachment Method 1 is used. The total conveyance for the 1%-annual-chance flood profile is $convtotalna$. The total conveyance for the floodway profile is $convtotalfw$. The difference in conveyance between the floodway profile and the 1%-annual-chance flood profile is more than 1%. The Normal Depth option with the same energy slope as the 1%-annual-chance flood profile must be used for both the 1%-annual-chance flood profile and the floodway profile and the plan should be rerun. This message may not be applicable when revising only a portion of a hydraulic model.	51604	No Action - Not applicable,

FW SW 05M1	The name of the stream is ($streamname$). Encroachment Method 1 is used. The floodway starting water-surface elevation is equal to the 1%-annual-chance starting water-surface elevation. Since the floodway width is narrower than the 1%-annual-chance top width the floodway starting WSEL should be higher than the 1%-annual-chance starting WSEL. The Normal depth option with the same energy slope as the 1%-annual-chance profile must be used for the floodway profile and the plan should be rerun. This message may not be applicable when revising only a portion of a hydraulic model.	51604	No Action - Know SWSE is the from downstream model reach.
MP SW 01DK	The name of the stream is ($streamname$). The flow regime is subcritical or mixed flow. Starting water-surface elevations are computed from Known WSELs as the downstream boundary condition. Provide backup information on Known water-surface elevations or use same energy slope for all the profiles as the starting boundary condition and rerun the plan.	MPCHECK	No Action - SWSE is from downstream model reach.
ST GD 02BD	This is the Downstream Bridge Section. There is only one bridge. However, the low cord line crosses the ground line at more than two locations. The ground and deck/roadway data should be checked.	72493(Bridge)	No Action - Structure is appropriately modeled.
ST GD 02BU	This is the Upstream Bridge Section. There is only one bridge. However, the low cord line crosses the ground line at more than two locations. The ground and deck/roadway data should be checked.	72493(Bridge)	No Action - Structure is appropriately modeled.
XS DF 01L	Divided flow. Flow code will be DL. The $assignedname$ flood discharge has a divided flow. The starting and ending stations of the cross section should not extend beyond the watershed boundary of the studied stream. Please review the extent of the cross section. If the cross section extends beyond the watershed boundary then the cross sections need to be trimmed and the HEC-RAS geometry file may need to be recreated using a GIS program. Or use the ineffective flow option, if it has not been considered, to limit the extent of the cross section or to block the divided flow area if it is a local depression.	80783	No Action - Cross section is appropriately modeled.

XS DF 01R	Divided flow. Flow code will be DR. The $assignedname$ flood discharge has a divided flow. The starting and ending stations of the cross section should not extend beyond the watershed boundary of the studied stream. Please review the extent of the cross section. If the cross section extends beyond the watershed boundary then the cross section needs to be trimmed and the HEC-RAS geometry file may need to be recreated using a GIS program. Or use the ineffective flow option, if it has not been considered, to limit the extent of the cross section or to block the divided flow area if it is a local depression.	86790; 87270	No Action - Cross section is appropriately modeled.
XS IF 02L	Flow code will be MIL. Multiple (block) Ineffective Stations are selected for the left overbank at this River Station. This is not Section 2 or Section 3 of Multiple Openings or Multiple Culverts. Please explain why the multiple blocks ineffective flow option was used. Consider using the normal ineffective flow option.	56885; 57395; 58795; 64191; 64745; 65297; 65868; 69462; 70139; 82573; 85096; 85633; 86263; 86790	No Action - Cross section is appropriately modeled.
XS IF 02R	Flow code will be MIR. Multiple (block) Ineffective Stations are selected for the right overbank at this River Station. This is not Section 2 or Section 3 of Multiple Openings or Multiple Culverts. Please justify why the Multiple Blocks Ineffective Flow option was used. Consider using the normal Ineffective Flow option.	86790	No Action - Cross section is appropriately modeled.
XS SP 01	Additional cross sections may need to be added between River Station Up of $secnoup$ and River Station Dn of $secnodn$ because all of the following conditions are met for the 1%-annual-chance flood. 1.Change in HV > 0.5; 2.Conv_Ratio < 0.7 or Conv_Ratio > 1.4 ; 3.DEPTH Ratio < 0.9 or DEPTH Ratio > 1.1; 4.TOPWID Ratio < 0.5 or TOPWID Ratio > 2.0; 5.Length Chnl Up / 500 > 1.1. The HEC-RAS geometry file may need to be recreated using a GIS program.	64745	No Action - Cross Section spacing meets modeling guidelines.
XS SW 01DK	The name of the stream is $streamname$. The flow regime is subcritical or mixed flow. Starting WSEL is computed from Known WSEL as the downstream boundary for $Assigned_Name$ flood. Provide backup information on Known WSEL or use energy slope as the downstream boundary.	51604	No Action - SWSE is from downstream model reach.

cHECk-RAS Report

HEC-RAS Project:	*musselshell_reach8.prj*
Plan File:	*musselshell_reach8.p03*
Geometry File:	*musselshell_reach8.g03*
Flow File:	*musselshell_reach8.f01*
Report Date:	*4/6/2016*

Message ID	Message	Cross sections affected	Comments
BR LF 01	This is ($strucname$). The selected profile is $profilename$. Type of flow is low flow because, 1. EGEL 3 of $egel3$ is less than or equal to MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is less than MxLoCdU of $mxlocdu$.	214157.4(Bridge-UP)	No Action - This is a statement not an error.
BR PW 01	This is a Bridge Section. The selected profile is $profilename$. Type of flow is sluice gate pressure and weir flow because, 1. EGEL 3 of $egel3$ is greater than MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is equal to or greater than MxLoCdU of $mxlocdu$. 3. WSEL 2 of $wsel2$ is less than MxLoCdD of $mxlocdd$.	214157.4(Bridge-UP)	No Action - This is a statement not an error.
MP SW 01DK	The name of the stream is ($streamname$). The flow regime is subcritical or mixed flow. Starting water-surface elevations are computed from Known WSELs as the downstream boundary condition. Provide backup information on Known water-surface elevations or use same energy slope for all the profiles as the starting boundary condition and rerun the plan.	MPCHECK	No Action - SWSE is from downstream model reach.
NT RC 05	The left overbank n-value of $nlob$ and the right overbank n-value of $nrob$ are less than or equal to the channel n-value of nch. Follow the procedure in (FHWA, 1984) to compute the n-value for the natural floodplain and the channel. Or follow the procedure in (USGS, 1977) to compute the n-value for urban development. Please submit supporting information on the evaluation of n-values.	208498; 209025	No Action - Higher channel n-value is necessary for subcritical flow condition.
ST GD 02BD	This is the Downstream Bridge Section. There is only one bridge. However, the low cord line crosses the ground line at more than two locations. The ground and deck/roadway data should be checked.	214157.4(Bridge)	No Action - Structure is appropriately modeled.
ST GD 02BU	This is the Upstream Bridge Section. There is only one bridge. However, the low cord line crosses the ground line at more than two locations. The ground and deck/roadway data should be checked.	214157.4(Bridge)	No Action - Structure is appropriately modeled.

ST IF 07S1L	This is Section 1. Left Ineffective flow option was considered at this section. However, it should be a fully expanded cross section. Ineffective flow stations and elevations should be cleared from this section, unless the areas beyond the ineffective flow stations are not within the flow path of the stream. This message should be ignored if this section is Section 3 of the downstream structure.	213805(Bridge)	No Action - Ineffective flow option for area not within flow path.
ST IF 07S1R	This is Section 1. Right Ineffective flow option was considered at this section. However, it should be a fully expanded cross section. Ineffective flow stations and elevations should be cleared from this section, unless the areas beyond the ineffective flow stations are not within the flow path of the stream. This message should be ignored if this section is Section 3 of the downstream structure.	213805(Bridge)	No Action - Ineffective flow option for area not within flow path.
ST IF 07S4L	This is Section 4. Left Ineffective flow option was considered at this section. However, it should be a fully expanded cross section. Ineffective flow stations and elevations should be cleared from this section, unless the areas beyond the ineffective flow stations are not within the flow path of the stream. This message should be ignored if this section is Section 2 of the upstream structure.	214366(Bridge)	No Action - Ineffective flow option for area not within flow path.
ST IF 07S4R	This is Section 4. Right Ineffective flow option was considered at this section. However, it should be a fully expanded cross section. Ineffective flow stations and elevations should be cleared from this section, unless the areas beyond the ineffective flow stations are not within the flow path of the stream. This message should be ignored if this section is Section 2 of the upstream structure.	214366(Bridge)	No Action - Ineffective flow option for area not within flow path.
XS DC 02	Constant discharge used for the entire profile for $assignedname$ flood. At least two discharges should be selected; one at the mouth and the other at the middle of the watershed or above the confluence of a tributary. Or provide explanation why only one discharge should be used. Other flood frequencies should also be checked.	MPCHECK	No Action - Model reach length does not include confluences or flow changes.

XS DF 01L	Divided flow. Flow code will be DL. The $assignedname$ flood discharge has a divided flow. The starting and ending stations of the cross section should not extend beyond the watershed boundary of the studied stream. Please review the extent of the cross section. If the cross section extends beyond the watershed boundary then the cross sections need to be trimmed and the HEC-RAS geometry file may need to be recreated using a GIS program. Or use the ineffective flow option, if it has not been considered, to limit the extent of the cross section or to block the divided flow area if it is a local depression.	205547; 207615; 214366; 216410; 218068	No Action - Cross section is appropriately modeled.
XS DF 01R	Divided flow. Flow code will be DR. The $assignedname$ flood discharge has a divided flow. The starting and ending stations of the cross section should not extend beyond the watershed boundary of the studied stream. Please review the extent of the cross section. If the cross section extends beyond the watershed boundary then the cross section needs to be trimmed and the HEC-RAS geometry file may need to be recreated using a GIS program. Or use the ineffective flow option, if it has not been considered, to limit the extent of the cross section or to block the divided flow area if it is a local depression.	205547; 214089	No Action - Cross section is appropriately modeled.
XS IF 02L	Flow code will be MIL. Multiple (block) Ineffective Stations are selected for the left overbank at this River Station. This is not Section 2 or Section 3 of Multiple Openings or Multiple Culverts. Please explain why the multiple blocks ineffective flow option was used. Consider using the normal ineffective flow option.	205014; 205547; 211630; 217492	No Action - Multiple block is required for differing flow path conditions.

cHECk-RAS Report

HEC-RAS Project:	*musselshell_reach8.prj*
Plan File:	*musselshell_reach8.p01*
Geometry File:	*musselshell_reach8.g03*
Flow File:	*musselshell_reach8.f02*
Report Date:	*4/6/2016*

Message ID	Message	Cross sections affected	Comments
BR LF 01	This is ($strucname$). The selected profile is $profilename$. Type of flow is low flow because, 1. EGEL 3 of $egel3$ is less than or equal to MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is less than MxLoCdU of $mxlocdu$.	214157.4(Bridge-UP)	No Action - This is a statement not an error.
FW SW 01M1	The name of the stream is ($streamname$). Encroachment Method 1 is used. Known WS option is used for both the 1%-annual-chance flood and floodway profiles. The floodway profile starting WSEL of $knownwsfw$ is not equal to the 1%-annual-chance flood starting WSEL of $knownws100yr$ plus the allowable surcharge value of $allowsurchrg$. The Normal Depth option with the energy slope of the 1%-annual-chance flood should be used for both profiles and the plan should be rerun. This message may not be applicable when revising only a portion of a hydraulic model.	205014	No Action - This is a statement is not applicable.
FW SW 04M1	The name of the stream is ($streamname$). Encroachment Method 1 is used. The total conveyance for the 1%-annual-chance flood profile is $convtotalna$. The total conveyance for the floodway profile is $convtotalfw$. The difference in conveyance between the floodway profile and the 1%-annual-chance flood profile is more than 1%. The Normal Depth option with the same energy slope as the 1%-annual-chance flood profile must be used for both the 1%-annual-chance flood profile and the floodway profile and the plan should be rerun. This message may not be applicable when revising only a portion of a hydraulic model.	205014	No Action - This is a statement is not applicable.

FW SW 05M1	The name of the stream is ($streamname$). Encroachment Method 1 is used. The floodway starting water-surface elevation is equal to the 1%-annual-chance starting water-surface elevation. Since the floodway width is narrower than the 1%-annual-chance top width the floodway starting WSEL should be higher than the 1%-annual-chance starting WSEL. The Normal depth option with the same energy slope as the 1%-annual-chance profile must be used for the floodway profile and the plan should be rerun. This message may not be applicable when revising only a portion of a hydraulic model.	205014	No Action - This is a statement is not applicable.
MP SW 01DK	The name of the stream is ($streamname$). The flow regime is subcritical or mixed flow. Starting water-surface elevations are computed from Known WSELs as the downstream boundary condition. Provide backup information on Known water-surface elevations or use same energy slope for all the profiles as the starting boundary condition and rerun the plan.	MPCHECK	No Action - SWSE is from downstream model reach.
NT RC 05	The left overbank n-value of $nlob$ and the right overbank n-value of $nrob$ are less than or equal to the channel n-value of nch. Follow the procedure in (FHWA, 1984) to compute the n-value for the natural floodplain and the channel. Or follow the procedure in (USGS, 1977) to compute the n-value for urban development. Please submit supporting information on the evaluation of n-values.	208498; 209025	No Action - Higher channel n-value is necessary for subcritical flow conditions.
ST GD 02BD	This is the Downstream Bridge Section. There is only one bridge. However, the low cord line crosses the ground line at more than two locations. The ground and deck/roadway data should be checked.	214157.4(Bridge)	No Action - Structure is appropriately modeled.
ST GD 02BU	This is the Upstream Bridge Section. There is only one bridge. However, the low cord line crosses the ground line at more than two locations. The ground and deck/roadway data should be checked.	214157.4(Bridge)	No Action - Structure is appropriately modeled.
ST IF 07S1L	This is Section 1. Left Ineffective flow option was considered at this section. However, it should be a fully expanded cross section. Ineffective flow stations and elevations should be cleared from this section, unless the areas beyond the ineffective flow stations are not within the flow path of the stream. This message should be ignored if this section is Section 3 of the downstream structure.	213805(Bridge)	No Action - Ineffective flow option for area not within flow path.

ST IF 07S1R	This is Section 1. Right Ineffective flow option was considered at this section. However, it should be a fully expanded cross section. Ineffective flow stations and elevations should be cleared from this section, unless the areas beyond the ineffective flow stations are not within the flow path of the stream. This message should be ignored if this section is Section 3 of the downstream structure.	213805(Bridge)	No Action - Ineffective flow option for area not within flow path.
ST IF 07S4L	This is Section 4. Left Ineffective flow option was considered at this section. However, it should be a fully expanded cross section. Ineffective flow stations and elevations should be cleared from this section, unless the areas beyond the ineffective flow stations are not within the flow path of the stream. This message should be ignored if this section is Section 2 of the upstream structure.	214366(Bridge)	No Action - Ineffective flow option for area not within flow path.
ST IF 07S4R	This is Section 4. Right Ineffective flow option was considered at this section. However, it should be a fully expanded cross section. Ineffective flow stations and elevations should be cleared from this section, unless the areas beyond the ineffective flow stations are not within the flow path of the stream. This message should be ignored if this section is Section 2 of the upstream structure.	214366(Bridge)	No Action - Ineffective flow option for area not within flow path.
XS DC 02	Constant discharge used for the entire profile for $assignedname$ flood. At least two discharges should be selected; one at the mouth and the other at the middle of the watershed or above the confluence of a tributary. Or provide explanation why only one discharge should be used. Other flood frequencies should also be checked.	MPCHECK	No Action - Model reach length does not include confluences or flow changes.
XS DF 01L	Divided flow. Flow code will be DL. The $assignedname$ flood discharge has a divided flow. The starting and ending stations of the cross section should not extend beyond the watershed boundary of the studied stream. Please review the extent of the cross section. If the cross section extends beyond the watershed boundary then the cross sections need to be trimmed and the HEC-RAS geometry file may need to be recreated using a GIS program. Or use the ineffective flow option, if it has not been considered, to limit the extent of the cross section or to block the divided flow area if it is a local depression.	205547; 207615; 210147; 210585; 211103; 212645; 214947; 217492	No Action - Cross section is appropriately modeled.

XS DF 01R	Divided flow. Flow code will be DR. The $assignedname$ flood discharge has a divided flow. The starting and ending stations of the cross section should not extend beyond the watershed boundary of the studied stream. Please review the extent of the cross section. If the cross section extends beyond the watershed boundary then the cross section needs to be trimmed and the HEC-RAS geometry file may need to be recreated using a GIS program. Or use the ineffective flow option, if it has not been considered, to limit the extent of the cross section or to block the divided flow area if it is a local depression.	205014; 205547; 216917	No Action - Cross section is appropriately modeled.
XS IF 01L	Flow code will be IL. The area left of the ineffective flow station may be considered effective. The $assignedname$ WSEL of $wsel$ is higher than the ground elevation $grelv$ of the Left Ineffective Flow Station. However, it is equal to or lower than the left ineffective flow elevation of $ineffell$. The lateral structure was not modeled downstream of this River Station. Lower the ineffective flow elevation to the ground elevation to consider the area left of the ineffective flow station as effective, or model a lateral structure if the overflow will take a different flow path. The ineffective flow elevation could be accepted if the area left of the ineffective flow station is non conveyance.	214366	No Action - Ineffective flow option for area not within flow path.
XS IF 01R	Flow code will be IR. The area to the right of the ineffective flow station may be considered effective. The $assignedname$ WSEL of $wsel$ is higher than the ground elevation $grelv$ of the Right Ineffective Flow Station. However, it is equal to or lower than the right ineffective flow elevation of $ineffelr$. The lateral structure was not modeled downstream of this River Station. Lower the ineffective flow elevation to the ground elevation to consider the area right of the ineffective flow station as effective, or model a lateral structure if the overflow will take a different flow path. The ineffective flow elevation could be accepted if the area right of the ineffective flow station is non conveyance.	214366	No Action - Ineffective flow option for area not within flow path.
XS IF 02L	Flow code will be MIL. Multiple (block) Ineffective Stations are selected for the left overbank at this River Station. This is not Section 2 or Section 3 of Multiple Openings or Multiple Culverts. Please explain why the multiple blocks ineffective flow option was used. Consider using the normal ineffective flow option.	205014; 205547; 211630; 217492	No Action - Multiple block is required for differing flow path conditions.

XS SW 01DK	The name of the stream is $streamname$. The flow regime is subcritical or mixed flow. Starting WSEL is computed from Known WSEL as the downstream boundary for $Assigned_Name$ flood. Provide backup information on Known WSEL or use energy slope as the downstream boundary.	205014	No Action - SWSE is from downstream model reach.

Appendix F – QA/QC Checklists

- Reach 2
- Reach 7
- Reach 8

HEC-RAS
QA Review Checklist

Project Name:	Musselshell Watershed Phase II Floodplain Study	Model:	Reach 2A
Project Number:	1447.041	MAS:	2015-02
Completed By:	Luke Carlson, PE, CFM	Date:	4/19/2016
Changes Made:	Mark Franchi, PE, CFM	Date:	4/20/2016

HEC-RAS Model Items:
Check appropriate box: *(If "NA" is checked, an explanation should be entered below item.)*

Yes	No	N/A	
☐	☒	☐	Does the model go through Critical Depth for any of the flows? If no, then go to next item. If yes, is this reasonable? If so, go to errors and check whether critical depth was calculated or assumed. If critical depth was calculated, run under mixed flow. If critical depth was assumed, model should be revised. *Corrected MAF*
☒	☐	☐	Model has been calibrated (if possible).
☒	☐	☐	2-year (50% Annual-Chance) event water surface is within channel.
☒	☐	☐	Multiple Critical Depth Search has been set.
☒	☐	☐	Energy Grade Line decreases is in downstream direction.
☐	☒	☐	Ineffective flows overtopping at correct elevation (roadway and other sections). *Corrected MAF*
☒	☐	☐	Continuity between X-SECs, especially when overtopping occurs.
☒	☐	☐	Flow widths are appropriate and/or calibrated.
☒	☐	☐	Right overbank flow at an acceptable event.
☒	☐	☐	Flow in channel.
☒	☐	☐	Left overbank flow at an acceptable event?
☒	☐	☐	Ineffective flow locations & elevations entered and checked. *Corrected MAF*
☒	☐	☐	Contraction/Expansion coefficients checked.
☐	☐	☒	Entrance loss coefficients checked. *(No culverts in this model reach.)*
☒	☐	☐	Structure X-SECs located at 1:1 upstream and 2:1 downstream and are fully expanded.
☒	☐	☐	Reach distances between X-SECs checked. (Use an aerial photograph with surveyed X-SEC locations for reference. The X-SECs should be labeled with stations used in HEC-RAS and/or the U/S and D/S distances).

HEC-RAS Model Items:
Check appropriate box: (If "NA" is checked, an explanation should be entered below item.)

Yes	No	N/A	
☒	☐	☐	Manning's "n" values checked and at each cross-section.
☒	☐	☐	Bank stations checked and are appropriate for each cross-section.
☒	☐	☐	Energy Method set for bridges in pressure flow or if ratio of EGL to Existing ground/Low chord to Existing Ground is less than or equal to 1.2. If ratio is greater than 1.2, use Pressure/Weir Method. If overtopping of the roadway is occurring, Pressure/Weir may need to be selected to calculate the weir flow over the road even if the bridge is not in pressure flow.
☐	☐	☒	Culvert calculation method set at highest "Upstream EG" or explain otherwise. *(No culverts in this model reach)*
☐	☐	☒	Scour calculations have been checked. *(No scour calculations with a floodplain study.)*
☐	☐	☒	Contraction Scour bank points are set outside of Bridge Opening. (This make HEC-RAS determine flows, depths, widths, etc). *(No scour calculations with a floodplain study.)*
☐	☐	☒	Pier Scour K2 Coefficient set at 1, if angle of attack of the flow is 0 degrees and bridge is not skewed or flow is parallel with the pier. Otherwise check HEC-18 for K2 based on L/a ratio. *(No scour calculations with a floodplain study.)*
☐	☐	☒	HEC-RAS error for Abutment Scour been accounted for by entering all of the data for the Abutment Scour calculation. *(No scour calculations with a floodplain study.)*
☐	☐	☒	Independent check of HEC-RAS scour calculations using Excel spreadsheets. *(No scour calculations with a floodplain study.)*
☐	☐	☒	Plot toes and tops of slope for proposed bridge on the topographic mapping for project to check for skew, channel centerline, and overall layout. Show skew of bridge and the roadway stationing (if available). *(No proposed bridge with a floodplain study.)*
☐	☐	☒	Multiple opening crossings set with conveyances only at the left and right extents of cross section. *(No multiple opening in this model reach)*
☒	☐	☐	Check HEC-RAS output Errors, Warnings and Notes.

Hydraulics Report Items:
Check appropriate box: *(If "NA" is checked, an explanation should be entered below item.)*

Yes	No	N/A	
☒	☐	☐	Version of HEC-RAS listed in report.
☒	☐	☐	High water events and floodplain risks within project limits discussed in the report.
☐	☐	☒	Existing and proposed overtopping events discussed in the report. *(No proposed bridge in a floodplain study.)*
☐	☐	☒	Water surface elevation(s) on the date of survey listed in report and the Bridge Rec Memo. *(No proposed bridge in this floodplain study.)*
☐	☐	☒	Hydraulic Data Summary Sheet completed. *(No proposed bridge in this floodplain study.)*
☐	☐	☒	Channel width modeled in HEC-RAS matches Report & Bridge Recommendation Memo. *(No proposed bridge in a floodplain study.)*

HEC-RAS
QA Review Checklist

Project Name:	Musselshell Watershed Phase II Floodplain Study	Model:	Reach 2B
Project Number:	1447.041	MAS:	2015-02
Completed By:	Luke Carlson, PE, CFM	Date:	4/20/2016
Changes Made:	Mark Franchi, PE, CFM	Date:	4/22/2016

HEC-RAS Model Items:
Check appropriate box: *(If "NA" is checked, an explanation should be entered below item.)*

Yes	No	N/A	
☐	☒	☐	Does the model go through Critical Depth for any of the flows? If no, then go to next item. If yes, is this reasonable? If so, go to errors and check whether critical depth was calculated or assumed. If critical depth was calculated, run under mixed flow. If critical depth was assumed, model should be revised. *Corrected MAF*
☒	☐	☐	Model has been calibrated (if possible).
☒	☐	☐	2-year (50% Annual-Chance) event water surface is within channel.
☒	☐	☐	Multiple Critical Depth Search has been set.
☒	☐	☐	Energy Grade Line decreases is in downstream direction.
☒	☐	☐	Ineffective flows overtopping at correct elevation (roadway and other sections). *Corrected MAF*
☒	☐	☐	Continuity between X-SECs, especially when overtopping occurs.
☒	☐	☐	Flow widths are appropriate and/or calibrated.
☒	☐	☐	Right overbank flow at an acceptable event.
☒	☐	☐	Flow in channel.
☒	☐	☐	Left overbank flow at an acceptable event?
☒	☐	☐	Ineffective flow locations & elevations entered and checked. *Corrected MAF*
☒	☐	☐	Contraction/Expansion coefficients checked. *Corrected MAF*
☐	☐	☒	Entrance loss coefficients checked. *(No culverts in this model reach.)*
☒	☐	☐	Structure X-SECs located at 1:1 upstream and 2:1 downstream and are fully expanded.
☒	☐	☐	Reach distances between X-SECs checked. (Use an aerial photograph with surveyed X-SEC locations for reference. The X-SECs should be labeled with stations used in HEC-RAS and/or the U/S and D/S distances).

HEC-RAS Model Items:
Check appropriate box: (If "NA" is checked, an explanation should be entered below item.)

Yes	No	N/A	
☒	☐	☐	Manning's "n" values checked and at each cross-section.
☒	☐	☐	Bank stations checked and are appropriate for each cross-section. *Corrected MAF*
☒	☐	☐	Energy Method set for bridges in pressure flow or if ratio of EGL to Existing ground/Low chord to Existing Ground is less than or equal to 1.2. If ratio is greater than 1.2, use Pressure/Weir Method. If overtopping of the roadway is occurring, Pressure/Weir may need to be selected to calculate the weir flow over the road even if the bridge is not in pressure flow.
☐	☐	☒	Culvert calculation method set at highest "Upstream EG" or explain otherwise. *(No culverts in this model reach)*
☐	☐	☒	Scour calculations have been checked. *(No scour calculations with a floodplain study.)*
☐	☐	☒	Contraction Scour bank points are set outside of Bridge Opening. (This make HEC-RAS determine flows, depths, widths, etc). *(No scour calculations with a floodplain study.)*
☐	☐	☒	Pier Scour K2 Coefficient set at 1, if angle of attack of the flow is 0 degrees and bridge is not skewed or flow is parallel with the pier. Otherwise check HEC-18 for K2 based on L/a ratio. *(No scour calculations with a floodplain study.)*
☐	☐	☒	HEC-RAS error for Abutment Scour been accounted for by entering all of the data for the Abutment Scour calculation. *(No scour calculations with a floodplain study.)*
☐	☐	☒	Independent check of HEC-RAS scour calculations using Excel spreadsheets. *(No scour calculations with a floodplain study.)*
☐	☐	☒	Plot toes and tops of slope for proposed bridge on the topographic mapping for project to check for skew, channel centerline, and overall layout. Show skew of bridge and the roadway stationing (if available). *(No proposed bridge with a floodplain study.)*
☐	☐	☒	Multiple opening crossings set with conveyances only at the left and right extents of cross section. *(No multiple opening in this model reach)*
☒	☐	☐	Check HEC-RAS output Errors, Warnings and Notes.

Hydraulics Report Items:
Check appropriate box: *(If "NA" is checked, an explanation should be entered below item.)*

Yes	No	N/A	
☒	☐	☐	Version of HEC-RAS listed in report.
☒	☐	☐	High water events and floodplain risks within project limits discussed in the report.
☐	☐	☒	Existing and proposed overtopping events discussed in the report. *(No proposed bridge in a floodplain study.)*
☐	☐	☒	Water surface elevation(s) on the date of survey listed in report and the Bridge Rec Memo. *(No proposed bridge in this floodplain study.)*
☐	☐	☒	Hydraulic Data Summary Sheet completed. *(No proposed bridge in this floodplain study.)*
☐	☐	☒	Channel width modeled in HEC-RAS matches Report & Bridge Recommendation Memo. *(No proposed bridge in a floodplain study.)*

HEC-RAS
QA Review Checklist

Project Name:	Musselshell Watershed Phase II Floodplain Study	Model:	Reach 2C
Project Number:	1447.041	MAS:	2015-02
Completed By:	Luke Carlson, PE, CFM	Date:	4/20/2016
Changes Made:	Mark Franchi, PE, CFM	Date:	4/26/2016

HEC-RAS Model Items:
Check appropriate box: *(If "NA" is checked, an explanation should be entered below item.)*

Yes	No	N/A	
☐	☒	☐	Does the model go through Critical Depth for any of the flows? If no, then go to next item. If yes, is this reasonable? If so, go to errors and check whether critical depth was calculated or assumed. If critical depth was calculated, run under mixed flow. If critical depth was assumed, model should be revised. *Corrected MAF*
☒	☐	☐	Model has been calibrated (if possible).
☒	☐	☐	2-year (50% Annual-Chance) event water surface is within channel.
☒	☐	☐	Multiple Critical Depth Search has been set.
☒	☐	☐	Energy Grade Line decreases is in downstream direction.
☒	☐	☐	Ineffective flows overtopping at correct elevation (roadway and other sections). *Corrected MAF*
☒	☐	☐	Continuity between X-SECs, especially when overtopping occurs.
☒	☐	☐	Flow widths are appropriate and/or calibrated.
☒	☐	☐	Right overbank flow at an acceptable event.
☒	☐	☐	Flow in channel.
☒	☐	☐	Left overbank flow at an acceptable event?
☒	☐	☐	Ineffective flow locations & elevations entered and checked. *Corrected MAF*
☒	☐	☐	Contraction/Expansion coefficients checked.
☐	☐	☒	Entrance loss coefficients checked. *(No culverts in this model reach.)*
☒	☐	☐	Structure X-SECs located at 1:1 upstream and 2:1 downstream and are fully expanded.
☒	☐	☐	Reach distances between X-SECs checked. (Use an aerial photograph with surveyed X-SEC locations for reference. The X-SECs should be labeled with stations used in HEC-RAS and/or the U/S and D/S distances).

HEC-RAS
QA Review Checklist

HEC-RAS Model Items:
Check appropriate box: (If "NA" is checked, an explanation should be entered below item.)

Yes	No	N/A	
☒	☐	☐	Manning's "n" values checked and at each cross-section.
☒	☐	☐	Bank stations checked and are appropriate for each cross-section.
☒	☐	☐	Energy Method set for bridges in pressure flow or if ratio of EGL to Existing ground/Low chord to Existing Ground is less than or equal to 1.2. If ratio is greater than 1.2, use Pressure/Weir Method. If overtopping of the roadway is occurring, Pressure/Weir may need to be selected to calculate the weir flow over the road even if the bridge is not in pressure flow.
☐	☐	☒	Culvert calculation method set at highest "Upstream EG" or explain otherwise. *(No culverts in this model reach)*
☐	☐	☒	Scour calculations have been checked. *(No scour calculations with a floodplain study.)*
☐	☐	☒	Contraction Scour bank points are set outside of Bridge Opening. (This make HEC-RAS determine flows, depths, widths, etc). *(No scour calculations with a floodplain study.)*
☐	☐	☒	Pier Scour K2 Coefficient set at 1, if angle of attack of the flow is 0 degrees and bridge is not skewed or flow is parallel with the pier. Otherwise check HEC-18 for K2 based on L/a ratio. *(No scour calculations with a floodplain study.)*
☐	☐	☒	HEC-RAS error for Abutment Scour been accounted for by entering all of the data for the Abutment Scour calculation. *(No scour calculations with a floodplain study.)*
☐	☐	☒	Independent check of HEC-RAS scour calculations using Excel spreadsheets. *(No scour calculations with a floodplain study.)*
☐	☐	☒	Plot toes and tops of slope for proposed bridge on the topographic mapping for project to check for skew, channel centerline, and overall layout. Show skew of bridge and the roadway stationing (if available). *(No proposed bridge with a floodplain study.)*
☐	☐	☒	Multiple opening crossings set with conveyances only at the left and right extents of cross section. *(No multiple opening in this model reach)*
☒	☐	☐	Check HEC-RAS output Errors, Warnings and Notes.

Hydraulics Report Items:
Check appropriate box: *(If "NA" is checked, an explanation should be entered below item.)*

Yes	No	N/A	
☒	☐	☐	Version of HEC-RAS listed in report.
☒	☐	☐	High water events and floodplain risks within project limits discussed in the report.
☐	☐	☒	Existing and proposed overtopping events discussed in the report. *(No proposed bridge in a floodplain study.)*
☐	☐	☒	Water surface elevation(s) on the date of survey listed in report and the Bridge Rec Memo. *(No proposed bridge in this floodplain study.)*
☐	☐	☒	Hydraulic Data Summary Sheet completed. *(No proposed bridge in this floodplain study.)*
☐	☐	☒	Channel width modeled in HEC-RAS matches Report & Bridge Recommendation Memo. *(No proposed bridge in a floodplain study.)*

HEC-RAS
QA Review Checklist

Project Name:	Musselshell Watershed Phase II Floodplain Study	Model:	Reach 7
Project Number:	1447.041	MAS:	2015-02
Completed By:	Luke Carlson, PE, CFM	Date:	4/19/2016
Changes Made:	Mark Franchi, PE, CFM	Date:	4/20/2016

HEC-RAS Model Items:
Check appropriate box: *(If "NA" is checked, an explanation should be entered below item.)*

Yes	No	N/A	
☐	☒	☐	Does the model go through Critical Depth for any of the flows? If no, then go to next item. If yes, is this reasonable? If so, go to errors and check whether critical depth was calculated or assumed. If critical depth was calculated, run under mixed flow. If critical depth was assumed, model should be revised.
☒	☐	☒	Model has been calibrated (if possible). *Corrected MAF*
☒	☐	☐	2-year (50% Annual-Chance) event water surface is within channel.
☒	☐	☐	Multiple Critical Depth Search has been set.
☒	☐	☐	Energy Grade Line decreases is in downstream direction.
☒	☐	☐	Ineffective flows overtopping at correct elevation (roadway and other sections).
☒	☐	☐	Continuity between X-SECs, especially when overtopping occurs.
☒	☐	☐	Flow widths are appropriate and/or calibrated.
☒	☐	☐	Right overbank flow at an acceptable event.
☒	☐	☐	Flow in channel.
☒	☐	☐	Left overbank flow at an acceptable event?
☒	☐	☐	Ineffective flow locations & elevations entered and checked.
☒	☐	☐	Contraction/Expansion coefficients checked.
☐	☐	☒	Entrance loss coefficients checked. *(No culverts in this model reach.)*
☒	☐	☐	Structure X-SECs located at 1:1 upstream and 2:1 downstream and are fully expanded.
☒	☐	☐	Reach distances between X-SECs checked. (Use an aerial photograph with surveyed X-SEC locations for reference. The X-SECs should be labeled with stations used in HEC-RAS and/or the U/S and D/S distances).

HEC-RAS
QA Review Checklist

HEC-RAS Model Items:
Check appropriate box: (If "NA" is checked, an explanation should be entered below item.)

Yes	No	N/A	
☒	☐	☐	Manning's "n" values checked and at each cross-section.
☒	☐	☐	Bank stations checked and are appropriate for each cross-section.
☒	☐	☐	Energy Method set for bridges in pressure flow or if ratio of EGL to Existing ground/Low chord to Existing Ground is less than or equal to 1.2. If ratio is greater than 1.2, use Pressure/Weir Method. If overtopping of the roadway is occurring, Pressure/Weir may need to be selected to calculate the weir flow over the road even if the bridge is not in pressure flow.
☐	☐	☒	Culvert calculation method set at highest "Upstream EG" or explain otherwise. *(No culverts in this model reach)*
☐	☐	☒	Scour calculations have been checked. *(No scour calculations with a floodplain study.)*
☐	☐	☒	Contraction Scour bank points are set outside of Bridge Opening. (This make HEC-RAS determine flows, depths, widths, etc). *(No scour calculations with a floodplain study.)*
☐	☐	☒	Pier Scour K2 Coefficient set at 1, if angle of attack of the flow is 0 degrees and bridge is not skewed or flow is parallel with the pier. Otherwise check HEC-18 for K2 based on L/a ratio. *(No scour calculations with a floodplain study.)*
☐	☐	☒	HEC-RAS error for Abutment Scour been accounted for by entering all of the data for the Abutment Scour calculation. *(No scour calculations with a floodplain study.)*
☐	☐	☒	Independent check of HEC-RAS scour calculations using Excel spreadsheets. *(No scour calculations with a floodplain study.)*
☐	☐	☒	Plot toes and tops of slope for proposed bridge on the topographic mapping for project to check for skew, channel centerline, and overall layout. Show skew of bridge and the roadway stationing (if available). *(No proposed bridge with a floodplain study.)*
☐	☐	☒	Multiple opening crossings set with conveyances only at the left and right extents of cross section. *(No multiple opening in this model reach)*
☒	☐	☐	Check HEC-RAS output Errors, Warnings and Notes.

Hydraulics Report Items:
Check appropriate box: *(If "NA" is checked, an explanation should be entered below item.)*

Yes	No	N/A	
☒	☐	☐	Version of HEC-RAS listed in report.
☒	☐	☐	High water events and floodplain risks within project limits discussed in the report.
☐	☐	☒	Existing and proposed overtopping events discussed in the report. *(No proposed bridge in a floodplain study.)*
☐	☐	☒	Water surface elevation(s) on the date of survey listed in report and the Bridge Rec Memo. *(No proposed bridge in this floodplain study.)*
☐	☐	☒	Hydraulic Data Summary Sheet completed. *(No proposed bridge in this floodplain study.)*
☐	☐	☒	Channel width modeled in HEC-RAS matches Report & Bridge Recommendation Memo. *(No proposed bridge in a floodplain study.)*

HEC-RAS
QA Review Checklist

Project Name:	Musselshell Watershed Phase II Floodplain Study	Model:	Reach 8
Project Number:	1447.041	MAS:	2015-02
Completed By:	Luke Carlson, PE, CFM	Date:	4/20/2016
Changes Made:	Mark Franchi, PE, CFM	Date:	4/25/2016

HEC-RAS Model Items:
Check appropriate box: *(If "NA" is checked, an explanation should be entered below item.)*

Yes	No	N/A	
☐	☒	☐	Does the model go through Critical Depth for any of the flows? If no, then go to next item. If yes, is this reasonable? If so, go to errors and check whether critical depth was calculated or assumed. If critical depth was calculated, run under mixed flow. If critical depth was assumed, model should be revised.
☒	☐	☐	Model has been calibrated (if possible).
☒	☐	☐	2-year (50% Annual-Chance) event water surface is within channel.
☒	☐	☐	Multiple Critical Depth Search has been set.
☒	☐	☐	Energy Grade Line decreases is in downstream direction.
☒	☐	☐	Ineffective flows overtopping at correct elevation (roadway and other sections). *Corrected MAF*
☒	☐	☐	Continuity between X-SECs, especially when overtopping occurs.
☒	☐	☐	Flow widths are appropriate and/or calibrated.
☒	☐	☐	Right overbank flow at an acceptable event.
☒	☐	☐	Flow in channel.
☒	☐	☐	Left overbank flow at an acceptable event?
☒	☐	☐	Ineffective flow locations & elevations entered and checked. *Corrected MAF*
☒	☐	☐	Contraction/Expansion coefficients checked.
☐	☐	☒	Entrance loss coefficients checked. *(No culverts in this model reach.)*
☒	☐	☐	Structure X-SECs located at 1:1 upstream and 2:1 downstream and are fully expanded.
☒	☐	☐	Reach distances between X-SECs checked. (Use an aerial photograph with surveyed X-SEC locations for reference. The X-SECs should be labeled with stations used in HEC-RAS and/or the U/S and D/S distances).

HEC-RAS Model Items:
Check appropriate box: (If "NA" is checked, an explanation should be entered below item.)

Yes	No	N/A	
☒	☐	☐	Manning's "n" values checked and at each cross-section.
☒	☐	☐	Bank stations checked and are appropriate for each cross-section.
☒	☐	☐	Energy Method set for bridges in pressure flow or if ratio of EGL to Existing ground/Low chord to Existing Ground is less than or equal to 1.2. If ratio is greater than 1.2, use Pressure/Weir Method. If overtopping of the roadway is occurring, Pressure/Weir may need to be selected to calculate the weir flow over the road even if the bridge is not in pressure flow.
☐	☐	☒	Culvert calculation method set at highest "Upstream EG" or explain otherwise. *(No culverts in this model reach)*
☐	☐	☒	Scour calculations have been checked. *(No scour calculations with a floodplain study.)*
☐	☐	☒	Contraction Scour bank points are set outside of Bridge Opening. (This make HEC-RAS determine flows, depths, widths, etc). *(No scour calculations with a floodplain study.)*
☐	☐	☒	Pier Scour K2 Coefficient set at 1, if angle of attack of the flow is 0 degrees and bridge is not skewed or flow is parallel with the pier. Otherwise check HEC-18 for K2 based on L/a ratio. *(No scour calculations with a floodplain study.)*
☐	☐	☒	HEC-RAS error for Abutment Scour been accounted for by entering all of the data for the Abutment Scour calculation. *(No scour calculations with a floodplain study.)*
☐	☐	☒	Independent check of HEC-RAS scour calculations using Excel spreadsheets. *(No scour calculations with a floodplain study.)*
☐	☐	☒	Plot toes and tops of slope for proposed bridge on the topographic mapping for project to check for skew, channel centerline, and overall layout. Show skew of bridge and the roadway stationing (if available). *(No proposed bridge with a floodplain study.)*
☐	☐	☒	Multiple opening crossings set with conveyances only at the left and right extents of cross section. *(No multiple opening in this model reach)*
☒	☐	☐	Check HEC-RAS output Errors, Warnings and Notes.

Hydraulics Report Items:
Check appropriate box: *(If "NA" is checked, an explanation should be entered below item.)*

Yes	No	N/A	
☒	☐	☐	Version of HEC-RAS listed in report.
☒	☐	☐	High water events and floodplain risks within project limits discussed in the report.
☐	☐	☒	Existing and proposed overtopping events discussed in the report. *(No proposed bridge in a floodplain study.)*
☐	☐	☒	Water surface elevation(s) on the date of survey listed in report and the Bridge Rec Memo. *(No proposed bridge in this floodplain study.)*
☐	☐	☒	Hydraulic Data Summary Sheet completed. *(No proposed bridge in this floodplain study.)*
☐	☐	☒	Channel width modeled in HEC-RAS matches Report & Bridge Recommendation Memo. *(No proposed bridge in a floodplain study.)*

Hydraulic Data

Quality Assurance (QA) Tracking

Project Name: Musselshell Watershed Project Phase II Flood Study

Mapping Activity Statement No.: 2015-02

Model: Musselshell County Reach 2A, RS 0 to RS 51604

Task Completed:

Submission Date:

QC Review Activity		
1. Ready for QC	LTP: Mark A. Franchi	Date: March 8, 2016
2. QC Review	QCR: Luke Carlson	Date: April 19, 2016
3. Concurrence	LTP: Mark A. Franchi	Date: April 20, 2016
4. Changes Made	LTP: Mark A. Franchi	Date: April 20, 2016
5. Changes Verified	QCR: Luke Carlson	Date: May 18, 2016

LTP – Lead Technical Professional:

QCR – Quality Control Reviewers:

Morrison Maierle
engineers - surveyors - planners - scientists

QA Review Checklist for Hydraulics

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
01	Is the computer program used for hydraulic modeling approved by FEMA, and is it a current model version?	The list of models approved by FEMA can be found at www.fema.gov/fhm/en_modl.shtm	Pass ☐ Fail ☐ N/A ☐	HEC-RAS v4.1.0
02	Does the model cover the reach of detailed study shown on the workmap?		Pass ☒ Fail ☐ N/A ☐	
03	Were both Multiple and Floodway models run?		Pass ☐ Fail ☐ N/A ☒	No floodway model with Limited Detail Study.
04	Does the flow used in the hydraulic model match with the Summary of Discharges table?		Pass ☒ Fail ☐ N/A ☐	
05	Do split flow reaches check with master flow diagram and table and check for continuity with hydrology?		Pass ☐ Fail ☐ N/A ☒	No split flow reaches.
06	Are the 1% AC flows identical for both multiple & floodway models?		Pass ☐ Fail ☐ N/A ☒	No floodway model with Limited Detail Study.
07	Is the starting water surface boundary condition of the model appropriate?		Pass ☒ Fail ☐ N/A ☐	
08	Is the Starting Water Surface Elevation for floodway run within 0.5 foot surcharge limit?		Pass ☐ Fail ☐ N/A ☒	No floodway model with Limited Detail Study.
09	Are all floodway surcharges less than or equal to 0.5 foot?		Pass ☐ Fail ☐ N/A ☒	No floodway model with Limited Detail Study.
10	Are all bridges visible on the workmap modeled or is a reason for not modeling provided?		Pass ☒ Fail ☐ N/A ☐	

QA Review Checklist for Hydraulics

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
11	Are bridges/culverts correctly modeled with high and low flow methods selection?		Pass ☒ Fail ☐ N/A ☐	
12	Are bridges/culverts coded with correct low chord, high chord, pier widths, coefficients and centerline stations?		Pass ☒ Fail ☐ N/A ☐	
13	Have ineffective flow areas, if any, been identified and blocked?		Pass ☒ Fail ☐ N/A ☐	See comments *Corrected MAF*
14	Does the River Stationing match the downstream channel reach lengths in the model?		Pass ☒ Fail ☐ N/A ☐	
15	Does the model's stationing as represented on the profile, match the stream distances shown on the map?		Pass ☒ Fail ☐ N/A ☐	
16	Are the left and right overbank distances adjusted for flow around curves?		Pass ☒ Fail ☐ N/A ☐	
17	Are cross-sections placed perpendicular to channel?		Pass ☒ Fail ☐ N/A ☐	See notes *Corrected MAF*
18	Are cross-section bank stations set at top of main channel bank?		Pass ☒ Fail ☐ N/A ☐	
19	Do cross-sections extend beyond the 0.2% AC floodplain?		Pass ☒ Fail ☐ N/A ☐	
20	Are cross-sections spaced correctly for general criteria of 900-1100 feet maximum between cross-sections?		Pass ☒ Fail ☐ N/A ☐	
21	Are split flow paths unencroached and identified?		Pass ☐ Fail ☐ N/A ☒	No split flow reaches.

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
22	Are all Check-RAS error messages resolved?		Pass ☒ Fail ☐ N/A ☐	
23	Are the Manning's n values used in the model within reasonable ranges?		Pass ☒ Fail ☐ N/A ☐	
24	Are Levees, if present, modeled appropriately based on whether they are certified according to NFIP (65.10)?		Pass ☐ Fail ☐ N/A ☒	No levees in this model reach.
25	Are expansion/contraction coefficients set at 0.3 and 0.5 at correct river stations for bridge/culvert crossings?		Pass ☒ Fail ☐ N/A ☐	
26	For areas where non-certified levees are shown on the workmap has analysis been provided for With & Without Levee conditions?		Pass ☐ Fail ☐ N/A ☒	No levees in this model reach.
27	Have sufficient backup hydraulic analysis been provided for any shallow flooding, or coastal areas, if any?		Pass ☐ Fail ☐ N/A ☒	No shallow flooding or coastal areas in this model reach.
28	Metadata file is submitted?		Pass ☒ Fail ☐ N/A ☐	
29	Hydraulic model is calibrated to available high water?		Pass ☒ Fail ☐ N/A ☐	
Profiles:				
30	Do the profiles meet FEMA format & font criteria?		Pass ☒ Fail ☐ N/A ☐	
31	Have appropriate vertical and horizontal scales been chosen?		Pass ☒ Fail ☐ N/A ☐	

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
32	Are elevations referenced to NAVD88 and shown?		Pass ☒ Fail ☐ N/A ☐	
33	Does the title block show the correct community or county and State names?		Pass ☒ Fail ☐ N/A ☐	
34	Does the beginning station reference match the labeling of the left side of the first profile for each flooding source?		Pass ☒ Fail ☐ N/A ☐	
35	Is the backwater or influence from the receiving stream shown on the profile?		Pass ☐ Fail ☐ N/A ☒	
36	Do the profiles have appropriately spaced lettered cross-sections?		Pass ☒ Fail ☐ N/A ☐	
37	Are all the corporate limits and confluences shown on the profile?		Pass ☐ Fail ☐ N/A ☒	
38	Do the bridge and culvert labels match with the labels shown on the base map?		Pass ☒ Fail ☐ N/A ☐	
39	Do bridge low chord, high chord, and river station match HEC-RAS model?		Pass ☒ Fail ☐ N/A ☐	
40	Do the locations of the lettered cross sections with respect to bridges and confluences match with the mapped locations?		Pass ☒ Fail ☐ N/A ☐	
Floodway Data Tables:				
41	Do the overall font & formatting meet FEMA criteria?		Pass ☐ Fail ☐ N/A ☒	No floodway

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
42	Is the proper community name and stream name shown?		Pass ☐ Fail ☐ N/A ☒	No floodway
43	Do the beginning station and measurement units match the profile?		Pass ☐ Fail ☐ N/A ☒	No floodway
44	Do the Cross Section Letter distances match the stations shown on the Profile?	(rounded to nearest foot)	Pass ☐ Fail ☐ N/A ☒	No floodway
45	Are the WIDTH and SECTION AREA in FDT exactly the same as the model output?	(rounded to nearest foot)	Pass ☐ Fail ☐ N/A ☒	No floodway
46	Do the Velocity numbers match the Mean Velocity output?	(rounded to one decimal point)	Pass ☐ Fail ☐ N/A ☒	No floodway
47	Are backwater elevations or influence elevations from the profile, if any, shown in the Regulatory Column?	(rounded to one decimal point)	Pass ☐ Fail ☐ N/A ☒	No floodway
48	Are the With and Without Floodway WSELs shown "without consideration of backwater", and do they match the model output?	(rounded to one decimal point)	Pass ☐ Fail ☐ N/A ☒	No floodway
49	Is the correct Datum shown?	Must match Profile and FIRM	Pass ☐ Fail ☐ N/A ☒	No floodway
50	Does the INCREASE column, equal the difference between WITH & WITHOUT columns?	(rounded to one decimal point)	Pass ☐ Fail ☐ N/A ☒	No floodway

Hydraulic Data

Quality Assurance (QA) Tracking

Project Name: Musselshell Watershed Project Phase II Flood Study

Mapping Activity Statement No.: 2015-02

Model: Musselshell County Reach 2B, RS 87270 to RS 208498

Task Completed:

Submission Date:

QC Review Activity		
1. Ready for QC	LTP: Mark A. Franchi	Date: March 8, 2016
2. QC Review	QCR: Luke Carlson	Date: April 20, 2016
3. Concurrence	LTP: Mark A. Franchi	Date: April 21, 2016
4. Changes Made	LTP: Mark A. Franchi	Date: April 22, 2016
5. Changes Verified	QCR: Luke Carlson	Date: May 18, 2016

LTP – Lead Technical Professional:

QCR – Quality Control Reviewers:

QA Review Checklist for Hydraulics

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
01	Is the computer program used for hydraulic modeling approved by FEMA, and is it a current model version?	The list of models approved by FEMA can be found at www.fema.gov/fhm/en_modl.shtm	Pass ☒ Fail ☐ N/A ☐	HEC-RAS v4.1.0
02	Does the model cover the reach of detailed study shown on the workmap?		Pass ☒ Fail ☐ N/A ☐	
03	Were both Multiple and Floodway models run?		Pass ☐ Fail ☐ N/A ☒	No floodway model with Limited Detail Study.
04	Does the flow used in the hydraulic model match with the Summary of Discharges table?		Pass ☒ Fail ☐ N/A ☐	
05	Do split flow reaches check with master flow diagram and table and check for continuity with hydrology?		Pass ☐ Fail ☐ N/A ☒	No split flow reaches.
06	Are the 1% AC flows identical for both multiple & floodway models?		Pass ☐ Fail ☐ N/A ☒	No floodway model with Limited Detail Study.
07	Is the starting water surface boundary condition of the model appropriate?		Pass ☒ Fail ☐ N/A ☐	
08	Is the Starting Water Surface Elevation for floodway run within 0.5 foot surcharge limit?		Pass ☐ Fail ☐ N/A ☒	No floodway model with Limited Detail Study.
09	Are all floodway surcharges less than or equal to 0.5 foot?		Pass ☐ Fail ☐ N/A ☒	No floodway model with Limited Detail Study.
10	Are all bridges visible on the workmap modeled or is a reason for not modeling provided?		Pass ☒ Fail ☐ N/A ☐	

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
11	Are bridges/culverts correctly modeled with high and low flow methods selection?		Pass ☒ Fail ☐ N/A ☐	*Corrected MAF*
12	Are bridges/culverts coded with correct low chord, high chord, pier widths, coefficients and centerline stations?		Pass ☒ Fail ☐ N/A ☐	*Corrected MAF*
13	Have ineffective flow areas, if any, been identified and blocked?		Pass ☒ Fail ☐ N/A ☐	*Corrected MAF*
14	Does the River Stationing match the downstream channel reach lengths in the model?		Pass ☒ Fail ☐ N/A ☐	
15	Does the model's stationing as represented on the profile, match the stream distances shown on the map?		Pass ☐ Fail ☐ N/A ☐	
16	Are the left and right overbank distances adjusted for flow around curves?		Pass ☒ Fail ☐ N/A ☐	
17	Are cross-sections placed perpendicular to channel?		Pass ☒ Fail ☐ N/A ☐	
18	Are cross-section bank stations set at top of main channel bank?		Pass ☒ Fail ☐ N/A ☐	Check XS 180749 *Corrected MAF*
19	Do cross-sections extend beyond the 0.2% AC floodplain?		Pass ☒ Fail ☐ N/A ☐	
20	Are cross-sections spaced correctly for general criteria of 900-1100 feet maximum between cross-sections?		Pass ☒ Fail ☐ N/A ☐	Exception at meander locations
21	Are split flow paths unencroached and identified?		Pass ☐ Fail ☐ N/A ☒	No split flow reaches.

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
22	Are all cHECk-RAS error messages resolved?		Pass ☒ Fail ☐ N/A ☐	*Resolved MAF*
23	Are the Manning's n values used in the model within reasonable ranges?		Pass ☒ Fail ☐ N/A ☐	
24	Are Levees, if present, modeled appropriately based on whether they are certified according to NFIP (65.10)?		Pass ☐ Fail ☐ N/A ☒	No levees in this model reach.
25	Are expansion/contraction coefficients set at 0.3 and 0.5 at correct river stations for bridge/culvert crossings?		Pass ☒ Fail ☐ N/A ☐	See notes *Corrected MAF*
26	For areas where non-certified levees are shown on the workmap has analysis been provided for With & Without Levee conditions?		Pass ☐ Fail ☐ N/A ☒	No levees in this model reach.
27	Have sufficient backup hydraulic analysis been provided for any shallow flooding, or coastal areas, if any?		Pass ☐ Fail ☐ N/A ☒	No shallow flooding or coastal areas in this model reach.
28	Metadata file is submitted?		Pass ☒ Fail ☐ N/A ☐	
29	Hydraulic model is calibrated to available high water?		Pass ☒ Fail ☐ N/A ☐	
Profiles:				
30	Do the profiles meet FEMA format & font criteria?		Pass ☒ Fail ☐ N/A ☐	
31	Have appropriate vertical and horizontal scales been chosen?		Pass ☒ Fail ☐ N/A ☐	

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
32	Are elevations referenced to NAVD88 and shown?		Pass ☒ Fail ☐ N/A ☐	
33	Does the title block show the correct community or county and State names?		Pass ☒ Fail ☐ N/A ☐	
34	Does the beginning station reference match the labeling of the left side of the first profile for each flooding source?		Pass ☒ Fail ☐ N/A ☐	
35	Is the backwater or influence from the receiving stream shown on the profile?		Pass ☒ Fail ☐ N/A ☐	
36	Do the profiles have appropriately spaced lettered cross-sections?		Pass ☒ Fail ☐ N/A ☐	
37	Are all the corporate limits and confluences shown on the profile?		Pass ☒ Fail ☐ N/A ☐	
38	Do the bridge and culvert labels match with the labels shown on the base map?		Pass ☒ Fail ☐ N/A ☐	
39	Do bridge low chord, high chord, and river station match HEC-RAS model?		Pass ☒ Fail ☐ N/A ☐	
40	Do the locations of the lettered cross sections with respect to bridges and confluences match with the mapped locations?		Pass ☒ Fail ☐ N/A ☐	
Floodway Data Tables:				
41	Do the overall font & formatting meet FEMA criteria?		Pass ☐ Fail ☐ N/A ☒	No floodway

QA Review Checklist for Hydraulics

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
42	Is the proper community name and stream name shown?		Pass ☐ Fail ☐ N/A ☒	No floodway
43	Do the beginning station and measurement units match the profile?		Pass ☐ Fail ☐ N/A ☒	No floodway
44	Do the Cross Section Letter distances match the stations shown on the Profile?	(rounded to nearest foot)	Pass ☐ Fail ☐ N/A ☒	No floodway
45	Are the WIDTH and SECTION AREA in FDT exactly the same as the model output?	(rounded to nearest foot)	Pass ☐ Fail ☐ N/A ☒	No floodway
46	Do the Velocity numbers match the Mean Velocity output?	(rounded to one decimal point)	Pass ☐ Fail ☐ N/A ☒	No floodway
47	Are backwater elevations or influence elevations from the profile, if any, shown in the Regulatory Column?	(rounded to one decimal point)	Pass ☐ Fail ☐ N/A ☒	No floodway
48	Are the With and Without Floodway WSELs shown "without consideration of backwater", and do they match the model output?	(rounded to one decimal point)	Pass ☐ Fail ☐ N/A ☒	No floodway
49	Is the correct Datum shown?	Must match Profile and FIRM	Pass ☐ Fail ☐ N/A ☒	No floodway
50	Does the INCREASE column, equal the difference between WITH & WITHOUT columns?	(rounded to one decimal point)	Pass ☐ Fail ☐ N/A ☒	No floodway

Hydraulic Data

Quality Assurance (QA) Tracking

Project Name: Musselshell Watershed Project Phase II Flood Study

Mapping Activity Statement No.: 2015-02

Model: Musselshell County Reach 2C, RS 220611 to RS 272397

Task Completed:

Submission Date:

QC Review Activity		
1. Ready for QC	LTP: Mark A. Franchi	Date: March 8, 2016
2. QC Review	QCR: Luke Carlson	Date: April 20, 2016
3. Concurrence	LTP: Mark A. Franchi	Date: April 26, 2016
4. Changes Made	LTP: Mark A. Franchi	Date: April 26, 2016
5. Changes Verified	QCR: Luke Carlson	Date: May 18, 2016

LTP – Lead Technical Professional:

QCR – Quality Control Reviewers:

QA Review Checklist for Hydraulics

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
01	Is the computer program used for hydraulic modeling approved by FEMA, and is it a current model version?	The list of models approved by FEMA can be found at www.fema.gov/fhm/en_modl.shtm	Pass ☒ Fail ☐ N/A ☐	HEC-RAS v4.1.0
02	Does the model cover the reach of detailed study shown on the workmap?		Pass ☒ Fail ☐ N/A ☐	
03	Were both Multiple and Floodway models run?		Pass ☐ Fail ☐ N/A ☒	No floodway model with Limited Detail Study.
04	Does the flow used in the hydraulic model match with the Summary of Discharges table?		Pass ☒ Fail ☐ N/A ☐	
05	Do split flow reaches check with master flow diagram and table and check for continuity with hydrology?		Pass ☐ Fail ☐ N/A ☒	No split flow reaches.
06	Are the 1% AC flows identical for both multiple & floodway models?		Pass ☐ Fail ☐ N/A ☒	No floodway model with Limited Detail Study.
07	Is the starting water surface boundary condition of the model appropriate?		Pass ☒ Fail ☐ N/A ☐	
08	Is the Starting Water Surface Elevation for floodway run within 0.5 foot surcharge limit?		Pass ☐ Fail ☐ N/A ☒	No floodway model with Limited Detail Study.
09	Are all floodway surcharges less than or equal to 0.5 foot?		Pass ☐ Fail ☐ N/A ☒	No floodway model with Limited Detail Study.
10	Are all bridges visible on the workmap modeled or is a reason for not modeling provided?		Pass ☒ Fail ☐ N/A ☐	

QA Review Checklist for Hydraulics

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
11	Are bridges/culverts correctly modeled with high and low flow methods selection?		Pass ☒ Fail ☐ N/A ☐	
12	Are bridges/culverts coded with correct low chord, high chord, pier widths, coefficients and centerline stations?		Pass ☒ Fail ☐ N/A ☐	
13	Have ineffective flow areas, if any, been identified and blocked?		Pass ☒ Fail ☐ N/A ☐	See notes *Corrected MAF*
14	Does the River Stationing match the downstream channel reach lengths in the model?		Pass ☒ Fail ☐ N/A ☐	
15	Does the model's stationing as represented on the profile, match the stream distances shown on the map?		Pass ☒ Fail ☐ N/A ☐	
16	Are the left and right overbank distances adjusted for flow around curves?		Pass ☒ Fail ☐ N/A ☐	
17	Are cross-sections placed perpendicular to channel?		Pass ☒ Fail ☐ N/A ☐	
18	Are cross-section bank stations set at top of main channel bank?		Pass ☒ Fail ☐ N/A ☐	
19	Do cross-sections extend beyond the 0.2% AC floodplain?		Pass ☒ Fail ☐ N/A ☐	
20	Are cross-sections spaced correctly for general criteria of 900-1100 feet maximum between cross-sections?		Pass ☒ Fail ☐ N/A ☐	Exception for meandered reaches.
21	Are split flow paths unencroached and identified?		Pass ☐ Fail ☐ N/A ☒	No split flow reaches.

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
22	Are all cHECk-RAS error messages resolved?		Pass ☒ Fail ☐ N/A ☐	*Resolved MAF*
23	Are the Manning's n values used in the model within reasonable ranges?		Pass ☒ Fail ☐ N/A ☐	
24	Are Levees, if present, modeled appropriately based on whether they are certified according to NFIP (65.10)?		Pass ☐ Fail ☐ N/A ☒	No levees in this model reach.
25	Are expansion/contraction coefficients set at 0.3 and 0.5 at correct river stations for bridge/culvert crossings?		Pass ☒ Fail ☐ N/A ☐	
26	For areas where non-certified levees are shown on the workmap has analysis been provided for With & Without Levee conditions?		Pass ☐ Fail ☐ N/A ☒	No levees in this model reach.
27	Have sufficient backup hydraulic analysis been provided for any shallow flooding, or coastal areas, if any?		Pass ☐ Fail ☐ N/A ☒	No shallow flooding or coastal areas in this model reach.
28	Metadata file is submitted?		Pass ☒ Fail ☐ N/A ☐	
29	Hydraulic model is calibrated to available high water?		Pass ☒ Fail ☐ N/A ☐	
Profiles:				
30	Do the profiles meet FEMA format & font criteria?		Pass ☒ Fail ☐ N/A ☐	
31	Have appropriate vertical and horizontal scales been chosen?		Pass ☒ Fail ☐ N/A ☐	

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
32	Are elevations referenced to NAVD88 and shown?		Pass ☒ Fail ☐ N/A ☐	
33	Does the title block show the correct community or county and State names?		Pass ☒ Fail ☐ N/A ☐	
34	Does the beginning station reference match the labeling of the left side of the first profile for each flooding source?		Pass ☒ Fail ☐ N/A ☐	
35	Is the backwater or influence from the receiving stream shown on the profile?		Pass ☒ Fail ☐ N/A ☐	
36	Do the profiles have appropriately spaced lettered cross-sections?		Pass ☒ Fail ☐ N/A ☐	
37	Are all the corporate limits and confluences shown on the profile?		Pass ☒ Fail ☐ N/A ☐	
38	Do the bridge and culvert labels match with the labels shown on the base map?		Pass ☒ Fail ☐ N/A ☐	
39	Do bridge low chord, high chord, and river station match HEC-RAS model?		Pass ☒ Fail ☐ N/A ☐	
40	Do the locations of the lettered cross sections with respect to bridges and confluences match with the mapped locations?		Pass ☒ Fail ☐ N/A ☐	
Floodway Data Tables:				
41	Do the overall font & formatting meet FEMA criteria?		Pass ☐ Fail ☐ N/A ☒	No floodway

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
42	Is the proper community name and stream name shown?		Pass ☐ Fail ☐ N/A ☒	No floodway
43	Do the beginning station and measurement units match the profile?		Pass ☐ Fail ☐ N/A ☒	No floodway
44	Do the Cross Section Letter distances match the stations shown on the Profile?	(rounded to nearest foot)	Pass ☐ Fail ☐ N/A ☒	No floodway
45	Are the WIDTH and SECTION AREA in FDT exactly the same as the model output?	(rounded to nearest foot)	Pass ☐ Fail ☐ N/A ☒	No floodway
46	Do the Velocity numbers match the Mean Velocity output?	(rounded to one decimal point)	Pass ☐ Fail ☐ N/A ☒	No floodway
47	Are backwater elevations or influence elevations from the profile, if any, shown in the Regulatory Column?	(rounded to one decimal point)	Pass ☐ Fail ☐ N/A ☒	No floodway
48	Are the With and Without Floodway WSELs shown "without consideration of backwater", and do they match the model output?	(rounded to one decimal point)	Pass ☐ Fail ☐ N/A ☒	No floodway
49	Is the correct Datum shown?	Must match Profile and FIRM	Pass ☐ Fail ☐ N/A ☒	No floodway
50	Does the INCREASE column, equal the difference between WITH & WITHOUT columns?	(rounded to one decimal point)	Pass ☐ Fail ☐ N/A ☒	No floodway

Hydraulic Data

Quality Assurance (QA) Tracking

Project Name: Musselshell Watershed Project Phase II Flood Study

Mapping Activity Statement No.: 2015-02

Model: Golden Valley County Reach 7

Task Completed:

Submission Date:

QC Review Activity		
1. Ready for QC	LTP: Mark A. Franchi	Date: April 8, 2016
2. QC Review	QCR: Luke Carlson	Date: April 19, 2016
3. Concurrence	LTP: Mark A. Franchi	Date: April 20, 2016
4. Changes Made	LTP: Mark A. Franchi	Date: April 20, 2016
5. Changes Verified	QCR: Luke Carlson	Date: May 18, 2016
FEMA PTS Review 1 Response		
6. Changes Made	LTP: Mark A. Franchi	Date: September 13, 2016
7. Changes Verified	QCR: Kristyn Mayernik	Date: September 14, 2016

LTP – Lead Technical Professional: Mark A. Franchi – MAF

QCR – Quality Control Reviewers: Luke Carlson – LDC

Kristyn Mayernik – KKM

QA Review Checklist for Hydraulics

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
01	Is the computer program used for hydraulic modeling approved by FEMA, and is it a current model version?	The list of models approved by FEMA can be found at www.fema.gov/fhm/en_modl.shtm	Pass ☐ Fail ☐ N/A ☐	HEC-RAS v4.1.0
02	Does the model cover the reach of detailed study shown on the workmap?		Pass ☒ Fail ☐ N/A ☐	
03	Were both Multiple Profile and Floodway models run?		Pass ☒ Fail ☐ N/A ☐	
04	Does the flow used in the hydraulic model match with the Summary of Discharges table?		Pass ☒ Fail ☐ N/A ☐	
05	Do split flow reaches check with master flow diagram and table and check for continuity with hydrology?		Pass ☐ Fail ☐ N/A ☒	No split flow reaches.
06	Are the 1% AC flows identical for both multiple & floodway models?		Pass ☒ Fail ☐ N/A ☐	
07	Is the starting water surface boundary condition of the model appropriate?		Pass ☒ Fail ☐ N/A ☐	
08	Is the Starting Water Surface Elevation for floodway run within 0.5 foot surcharge limit?		Pass ☒ Fail ☐ N/A ☐	
09	Are all floodway surcharges less than or equal to 0.5 foot?		Pass ☒ Fail ☐ N/A ☐	
10	Are all bridges visible on the workmap modeled or is a reason for not modeling provided?		Pass ☒ Fail ☐ N/A ☐	

QA Review Checklist for Hydraulics

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
11	Are bridges/culverts correctly modeled with high and low flow methods selection?		Pass ☒ Fail ☐ N/A ☐	
12	Are bridges/culverts coded with correct low chord, high chord, pier widths, coefficients and centerline stations?		Pass ☒ Fail ☐ N/A ☐	
13	Have ineffective flow areas, if any, been identified and blocked?		Pass ☒ Fail ☐ N/A ☐	
14	Does the River Stationing match the downstream channel reach lengths in the model?		Pass ☒ Fail ☐ N/A ☐	
15	Does the model's stationing as represented on the profile, match the stream distances shown on the map?		Pass ☒ Fail ☐ N/A ☐	
16	Are the left and right overbank distances adjusted for flow around curves?		Pass ☒ Fail ☐ N/A ☐	
17	Are cross-sections placed perpendicular to channel?		Pass ☒ Fail ☐ N/A ☐	
18	Are cross-section bank stations set at top of main channel bank?		Pass ☒ Fail ☐ N/A ☐	
19	Do cross-sections extend beyond the 0.2% AC floodplain?		Pass ☒ Fail ☐ N/A ☐	
20	Are cross-sections spaced correctly for general criteria of 500-600 feet maximum between cross-sections?		Pass ☒ Fail ☐ N/A ☐	Yes, with exceptions for meanders.
21	Are split flow paths unencroached and identified?		Pass ☐ Fail ☐ N/A ☒	No split flow reaches.

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
22	Are all cHECk-RAS error messages resolved?		Pass ☒ Fail ☐ N/A ☐	
23	Are the Manning's n values used in the model within reasonable ranges?		Pass ☒ Fail ☐ N/A ☐	
24	Are Levees, if present, modeled appropriately based on whether they are certified according to NFIP (65.10)?		Pass ☐ Fail ☐ N/A ☒	No levees in this model reach.
25	Are expansion/contraction coefficients set at 0.3 and 0.5 at correct river stations for bridge/culvert crossings?		Pass ☒ Fail ☐ N/A ☐	
26	For areas where non-certified levees are shown on the workmap has analysis been provided for With & Without Levee conditions?		Pass ☐ Fail ☐ N/A ☒	No levees in this model reach.
27	Have sufficient backup hydraulic analysis been provided for any shallow flooding, or coastal areas, if any?		Pass ☐ Fail ☐ N/A ☒	No shallow flooding or coastal areas in this model reach.
28	Metadata file is submitted?		Pass ☒ Fail ☐ N/A ☐	
29	Hydraulic model is calibrated to available high water?		Pass ☒ Fail ☐ N/A ☐	*Calibrated MAF*
Profiles:				
30	Do the profiles meet FEMA format & font criteria?		Pass ☒ Fail ☐ N/A ☐	
31	Have appropriate vertical and horizontal scales been chosen?		Pass ☒ Fail ☐ N/A ☐	

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
32	Are elevations referenced to NAVD88 and shown?		Pass ☒ Fail ☐ N/A ☐	
33	Does the title block show the correct community or county and State names?		Pass ☒ Fail ☐ N/A ☐	
34	Does the beginning station reference match the labeling of the left side of the first profile for each flooding source?		Pass ☒ Fail ☐ N/A ☐	
35	Is the backwater or influence from the receiving stream shown on the profile?		Pass ☒ Fail ☐ N/A ☐	
36	Do the profiles have appropriately spaced lettered cross-sections?		Pass ☒ Fail ☐ N/A ☐	
37	Are all the corporate limits and confluences shown on the profile?		Pass ☒ Fail ☐ N/A ☐	
38	Do the bridge and culvert labels match with the labels shown on the base map?		Pass ☒ Fail ☐ N/A ☐	
39	Do bridge low chord, high chord, and river station match HEC-RAS model?		Pass ☒ Fail ☐ N/A ☐	
40	Do the locations of the lettered cross sections with respect to bridges and confluences match with the mapped locations?		Pass ☒ Fail ☐ N/A ☐	
Floodway Data Tables:				
41	Do the overall font & formatting meet FEMA criteria?		Pass ☒ Fail ☐ N/A ☐	

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
42	Is the proper community name and stream name shown?		Pass ☒ Fail ☐ N/A ☐	
43	Do the beginning station and measurement units match the profile?		Pass ☒ Fail ☐ N/A ☐	
44	Do the Cross Section Letter distances match the stations shown on the Profile?	(rounded to nearest foot)	Pass ☒ Fail ☐ N/A ☐	
45	Are the WIDTH and SECTION AREA in FDT exactly the same as the model output?	(rounded to nearest foot)	Pass ☒ Fail ☐ N/A ☐	
46	Do the Velocity numbers match the Mean Velocity output?	(rounded to one decimal point)	Pass ☒ Fail ☐ N/A ☐	
47	Are backwater elevations or influence elevations from the profile, if any, shown in the Regulatory Column?	(rounded to one decimal point)	Pass ☐ Fail ☐ N/A ☒	
48	Are the With and Without Floodway WSELs shown "without consideration of backwater", and do they match the model output?	(rounded to one decimal point)	Pass ☒ Fail ☐ N/A ☐	
49	Is the correct Datum shown?	Must match Profile and FIRM	Pass ☒ Fail ☐ N/A ☐	
50	Does the INCREASE column, equal the difference between WITH & WITHOUT columns?	(rounded to one decimal point)	Pass ☒ Fail ☐ N/A ☐	
FEMA PTS Review 1 Response				
51	Floodway Increase ≤ 0.5 feet	(rounded to one decimal point)	Pass ☒ Fail ☐ N/A ☐	

Hydraulic Data

Quality Assurance (QA) Tracking

Project Name: Musselshell Watershed Project Phase II Flood Study

Mapping Activity Statement No.: 2015-02

Model: Musselshell County Reach 8

Task Completed:

Submission Date:

QC Review Activity		
1. Ready for QC	LTP: Mark A. Franchi	Date: March 8, 2016
2. QC Review	QCR: Luke Carlson	Date: March 20, 2016
3. Concurrence	LTP: Mark A. Franchi	Date: March 25, 2016
4. Changes Made	LTP: Mark A. Franchi	Date: March 25, 2016
5. Changes Verified	QCR: Luke Carlson	Date: May 18, 2016

LTP – Lead Technical Professional:

QCR – Quality Control Reviewers:

QA Review Checklist for Hydraulics

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
01	Is the computer program used for hydraulic modeling approved by FEMA, and is it a current model version?	The list of models approved by FEMA can be found at www.fema.gov/fhm/en_modl.shtm	Pass ☒ Fail ☐ N/A ☐	HEC-RAS v4.1.0
02	Does the model cover the reach of detailed study shown on the workmap?		Pass ☒ Fail ☐ N/A ☐	
03	Were both Multiple and Floodway models run?		Pass ☒ Fail ☐ N/A ☐	
04	Does the flow used in the hydraulic model match with the Summary of Discharges table?		Pass ☒ Fail ☐ N/A ☐	
05	Do split flow reaches check with master flow diagram and table and check for continuity with hydrology?		Pass ☐ Fail ☐ N/A ☒	No split flow reaches.
06	Are the 1% AC flows identical for both multiple & floodway models?		Pass ☒ Fail ☐ N/A ☐	
07	Is the starting water surface boundary condition of the model appropriate?		Pass ☒ Fail ☐ N/A ☐	
08	Is the Starting Water Surface Elevation for floodway run within 0.5 foot surcharge limit?		Pass ☒ Fail ☐ N/A ☐	
09	Are all floodway surcharges less than or equal to 0.5 foot?		Pass ☒ Fail ☐ N/A ☐	
10	Are all bridges visible on the workmap modeled or is a reason for not modeling provided?		Pass ☒ Fail ☐ N/A ☐	

QA Review Checklist for Hydraulics

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
11	Are bridges/culverts correctly modeled with high and low flow methods selection?		Pass ☒ Fail ☐ N/A ☐	
12	Are bridges/culverts coded with correct low chord, high chord, pier widths, coefficients and centerline stations?		Pass ☒ Fail ☐ N/A ☐	
13	Have ineffective flow areas, if any, been identified and blocked?		Pass ☒ Fail ☐ N/A ☐	See notes *Corrected MAF*
14	Does the River Stationing match the downstream channel reach lengths in the model?		Pass ☒ Fail ☐ N/A ☐	
15	Does the model's stationing as represented on the profile, match the stream distances shown on the map?		Pass ☒ Fail ☐ N/A ☐	
16	Are the left and right overbank distances adjusted for flow around curves?		Pass ☒ Fail ☐ N/A ☐	
17	Are cross-sections placed perpendicular to channel?		Pass ☒ Fail ☐ N/A ☐	
18	Are cross-section bank stations set at top of main channel bank?		Pass ☒ Fail ☐ N/A ☐	
19	Do cross-sections extend beyond the 0.2% AC floodplain?		Pass ☒ Fail ☐ N/A ☐	
20	Are cross-sections spaced correctly for general criteria of 500-600 feet maximum between cross-sections?		Pass ☒ Fail ☐ N/A ☐	
21	Are split flow paths unencroached and identified?		Pass ☐ Fail ☐ N/A ☒	No split flow reaches.

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
22	Are all cHECk-RAS error messages resolved?		Pass ☒ Fail ☐ N/A ☐	
23	Are the Manning's n values used in the model within reasonable ranges?		Pass ☒ Fail ☐ N/A ☐	*Corrected MAF*
24	Are Levees, if present, modeled appropriately based on whether they are certified according to NFIP (65.10)?		Pass ☐ Fail ☐ N/A ☒	No levees in this model reach.
25	Are expansion/contraction coefficients set at 0.3 and 0.5 at correct river stations for bridge/culvert crossings?		Pass ☒ Fail ☐ N/A ☐	
26	For areas where non-certified levees are shown on the workmap has analysis been provided for With & Without Levee conditions?		Pass ☐ Fail ☐ N/A ☒	No levees in this model reach.
27	Have sufficient backup hydraulic analysis been provided for any shallow flooding, or coastal areas, if any?		Pass ☐ Fail ☐ N/A ☒	No shallow flooding or coastal areas in this model reach.
28	Metadata file is submitted?		Pass ☒ Fail ☐ N/A ☐	
29	Hydraulic model is calibrated to available high water?		Pass ☒ Fail ☐ N/A ☐	
Profiles:				
30	Do the profiles meet FEMA format & font criteria?		Pass ☒ Fail ☐ N/A ☐	
31	Have appropriate vertical and horizontal scales been chosen?		Pass ☒ Fail ☐ N/A ☐	

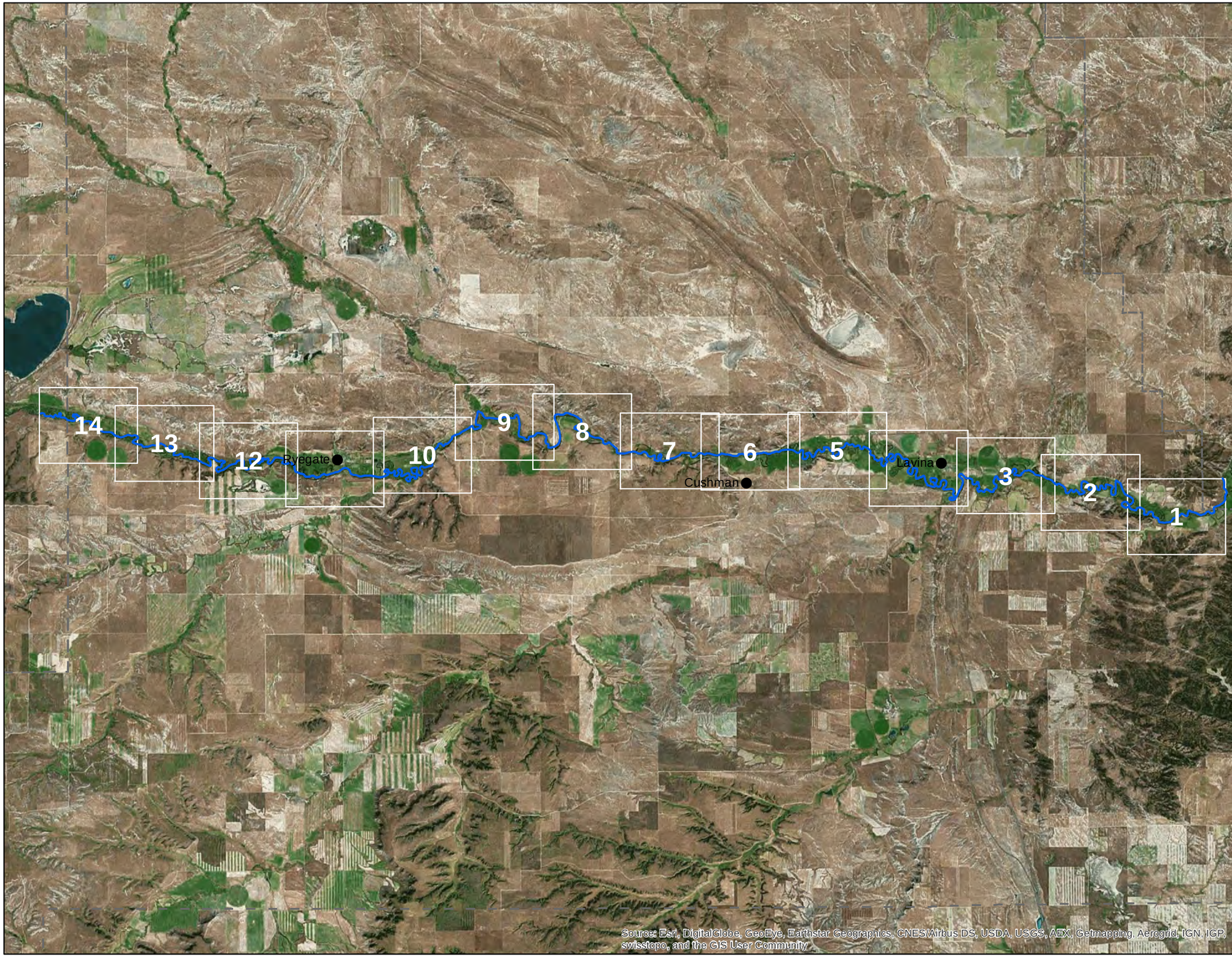
No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
32	Are elevations referenced to NAVD88 and shown?		Pass ☒ Fail ☐ N/A ☐	
33	Does the title block show the correct community or county and State names?		Pass ☒ Fail ☐ N/A ☐	
34	Does the beginning station reference match the labeling of the left side of the first profile for each flooding source?		Pass ☒ Fail ☐ N/A ☐	
35	Is the backwater or influence from the receiving stream shown on the profile?		Pass ☐ Fail ☐ N/A ☒	
36	Do the profiles have appropriately spaced lettered cross-sections?		Pass ☒ Fail ☐ N/A ☐	
37	Are all the corporate limits and confluences shown on the profile?		Pass ☐ Fail ☐ N/A ☒	
38	Do the bridge and culvert labels match with the labels shown on the base map?		Pass ☒ Fail ☐ N/A ☐	
39	Do bridge low chord, high chord, and river station match HEC-RAS model?		Pass ☒ Fail ☐ N/A ☐	
40	Do the locations of the lettered cross sections with respect to bridges and confluences match with the mapped locations?		Pass ☒ Fail ☐ N/A ☐	
Floodway Data Tables:				
41	Do the overall font & formatting meet FEMA criteria?		Pass ☒ Fail ☐ N/A ☐	

QA Review Checklist for Hydraulics

No.	Hydraulic Review	Definition	Pass Fail N/A	Reviewer Comments
42	Is the proper community name and stream name shown?		Pass ☒ Fail ☐ N/A ☐	
43	Do the beginning station and measurement units match the profile?		Pass ☒ Fail ☐ N/A ☐	
44	Do the Cross Section Letter distances match the stations shown on the Profile?	(rounded to nearest foot)	Pass ☒ Fail ☐ N/A ☐	
45	Are the WIDTH and SECTION AREA in FDT exactly the same as the model output?	(rounded to nearest foot)	Pass ☒ Fail ☐ N/A ☐	
46	Do the Velocity numbers match the Mean Velocity output?	(rounded to one decimal point)	Pass ☒ Fail ☐ N/A ☐	
47	Are backwater elevations or influence elevations from the profile, if any, shown in the Regulatory Column?	(rounded to one decimal point)	Pass ☐ Fail ☐ N/A ☒	
48	Are the With and Without Floodway WSELs shown “without consideration of backwater”, and do they match the model output?	(rounded to one decimal point)	Pass ☒ Fail ☐ N/A ☐	
49	Is the correct Datum shown?	Must match Profile and FIRM	Pass ☒ Fail ☐ N/A ☐	
50	Does the INCREASE column, equal the difference between WITH & WITHOUT columns?	(rounded to one decimal point)	Pass ☒ Fail ☐ N/A ☐	

Appendix G – CSLF

GOLDEN VALLEY COUNTY CHANGES SINCE LAST FIRM - PROPOSED STRUCTURE CHANGES FOR FLOODPLAIN INDEX



LEGEND

- towns
- Musselshell River
- Golden Valley Index
- County Boundary

Labels

- A Cross Section Letter 79,726 River Station
- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

0 6,250 12,500 18,750 Feet

CSLF Work Map - Musselshell Watershed Project - Ph. II
Golden Valley County, MT Risk MAP - MAS No. 2015-02
NAIP 2013, Horizontal Datum: NAD83
Topographic Data, LiDAR 2012
Hozontal Datum: NAD83, Vertical Datum: NAVD88, Feet
Submitted 1/13/2017

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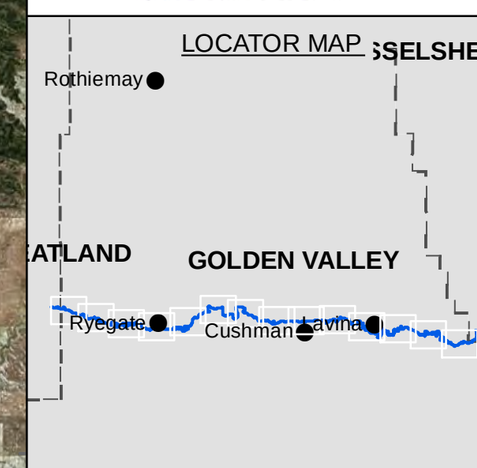
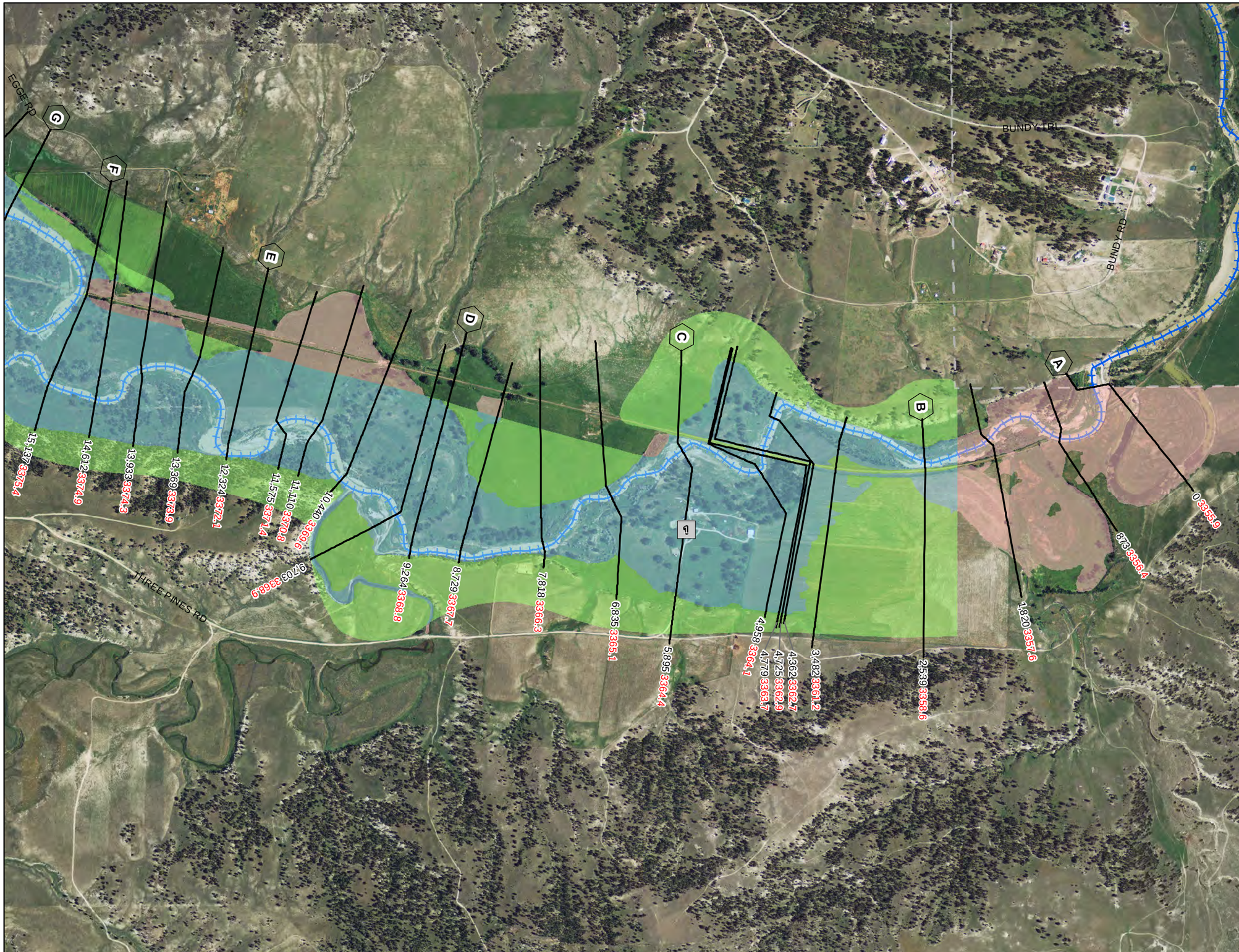
LOCATOR MAP



Musselshell River Index Map



CHANGES SINCE LAST FIRM - PROPOSED STRUCTURE CHANGES FOR FLOODPLAIN

January 13, 2017

LEGEND

- Proposed Floodplain - Increase
- Proposed Floodplain - Decrease
- Proposed Floodplain - No Change
- 1 Structure - In Increase Area
- 1 Structure - In Decrease Area
- 1 Structure - In No Change Area

Labels

- A Cross Section Letter — 79,726 River Station
- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

0 500 1,000 1,500 Feet

Note: This map shows structures in the proposed Floodplain change areas. Where any portion of a structure intersects a Floodplain Increase area, the structure has been included in the "Increase Area" category.

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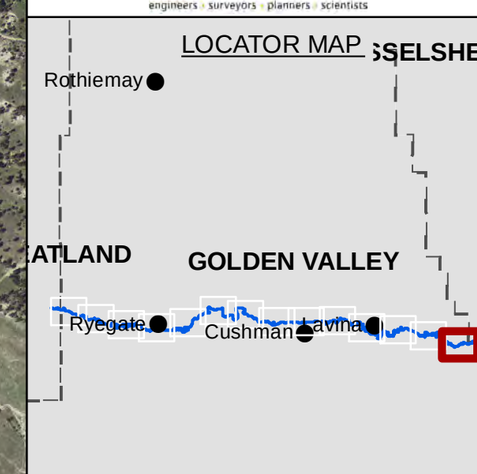
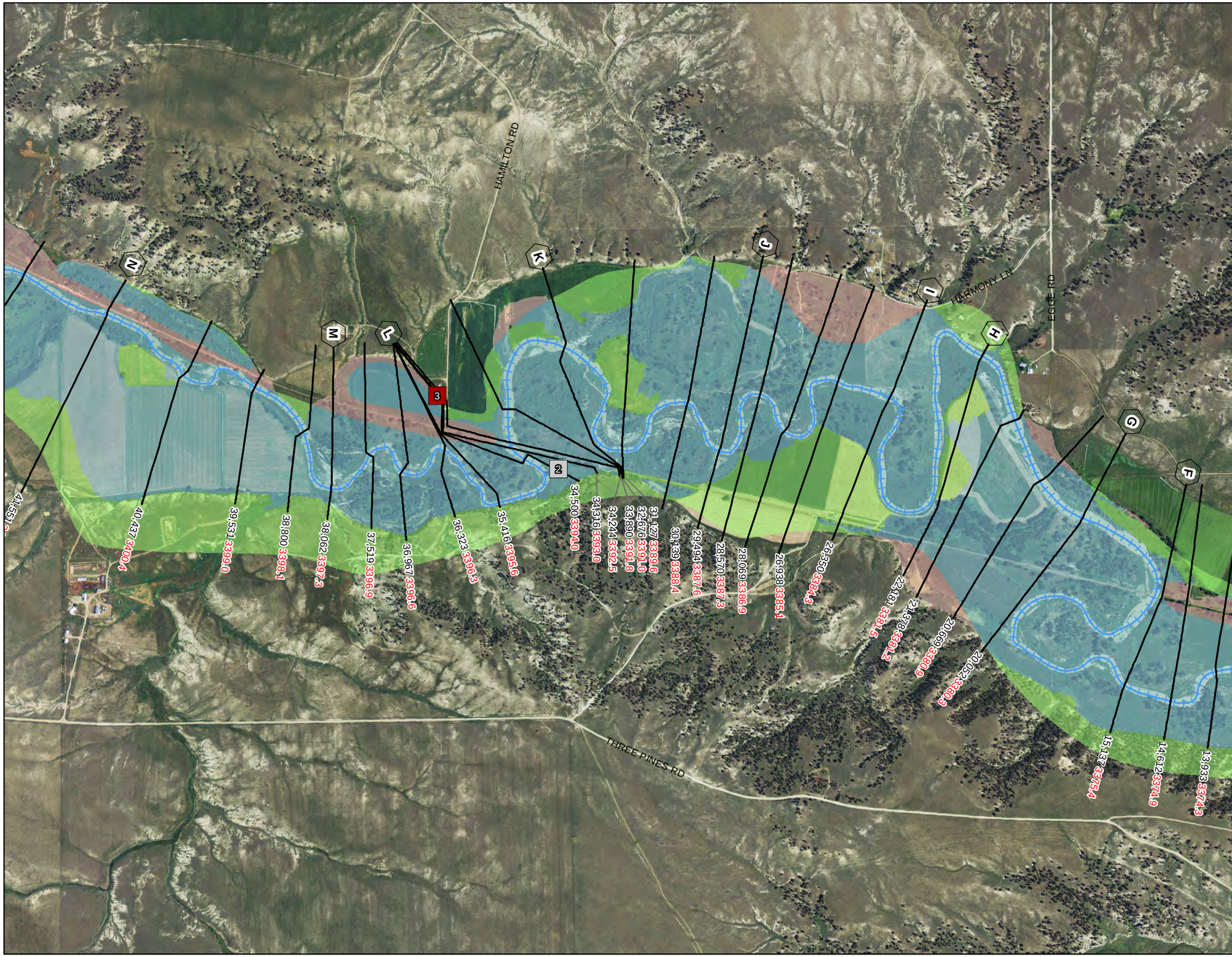
LOCATOR MAP



Musselshell River Map 1 of 14



CHANGES SINCE LAST FIRM - PROPOSED STRUCTURE CHANGES FOR FLOODPLAIN

January 13, 2017

LEGEND

- Proposed Floodplain - Increase
- Proposed Floodplain - Decrease
- Proposed Floodplain - No Change
- 1 Structure - In Increase Area
- 1 Structure - In Decrease Area
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Labels

- A Cross Section Letter — 79,726 River Station
- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

0 500 1,000 1,500 Feet

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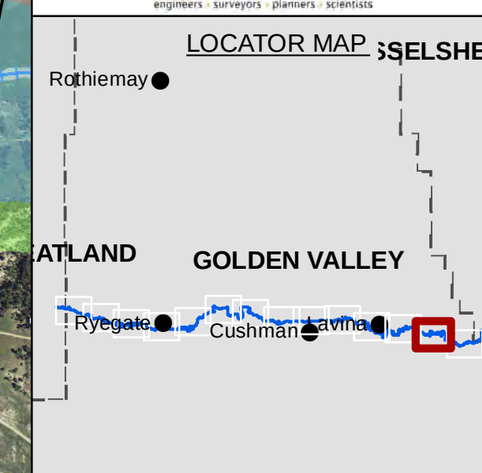
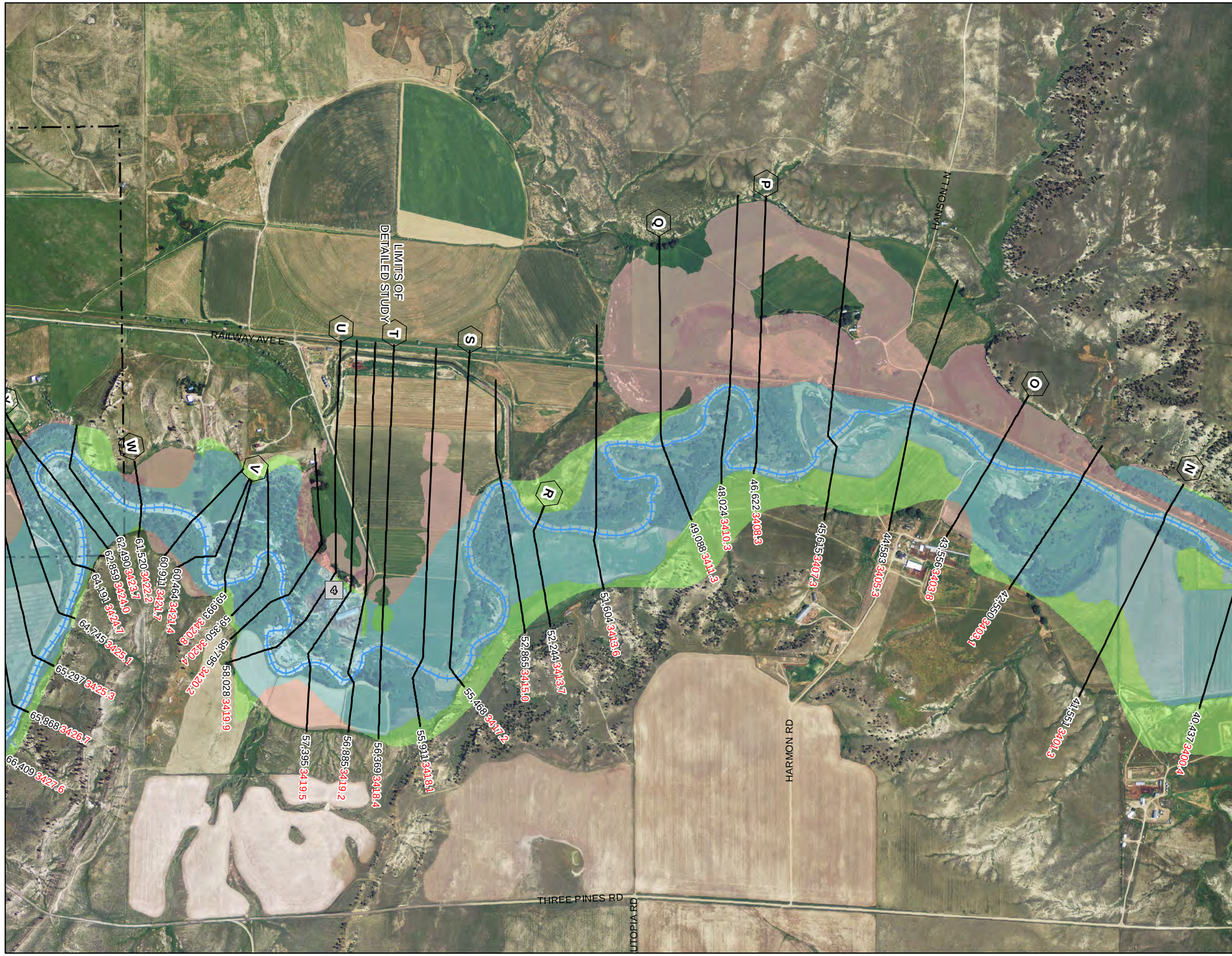
LOCATOR MAP



Musselshell River Map 2 of 14



CHANGES SINCE LAST FIRM - PROPOSED STRUCTURE CHANGES FOR FLOODPLAIN

January 13, 2017

LEGEND

- Proposed Floodplain - Increase
- Proposed Floodplain - Decrease
- Proposed Floodplain - No Change
- Structure - In Increase Area
- Structure - In Decrease Area
- Structure - In No Change Area

Labels

- Cross Section Letter 79,726 River Station
- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

0 500 1,000 1,500 Feet

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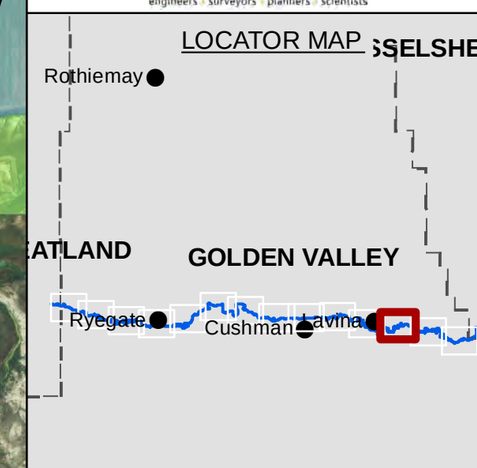
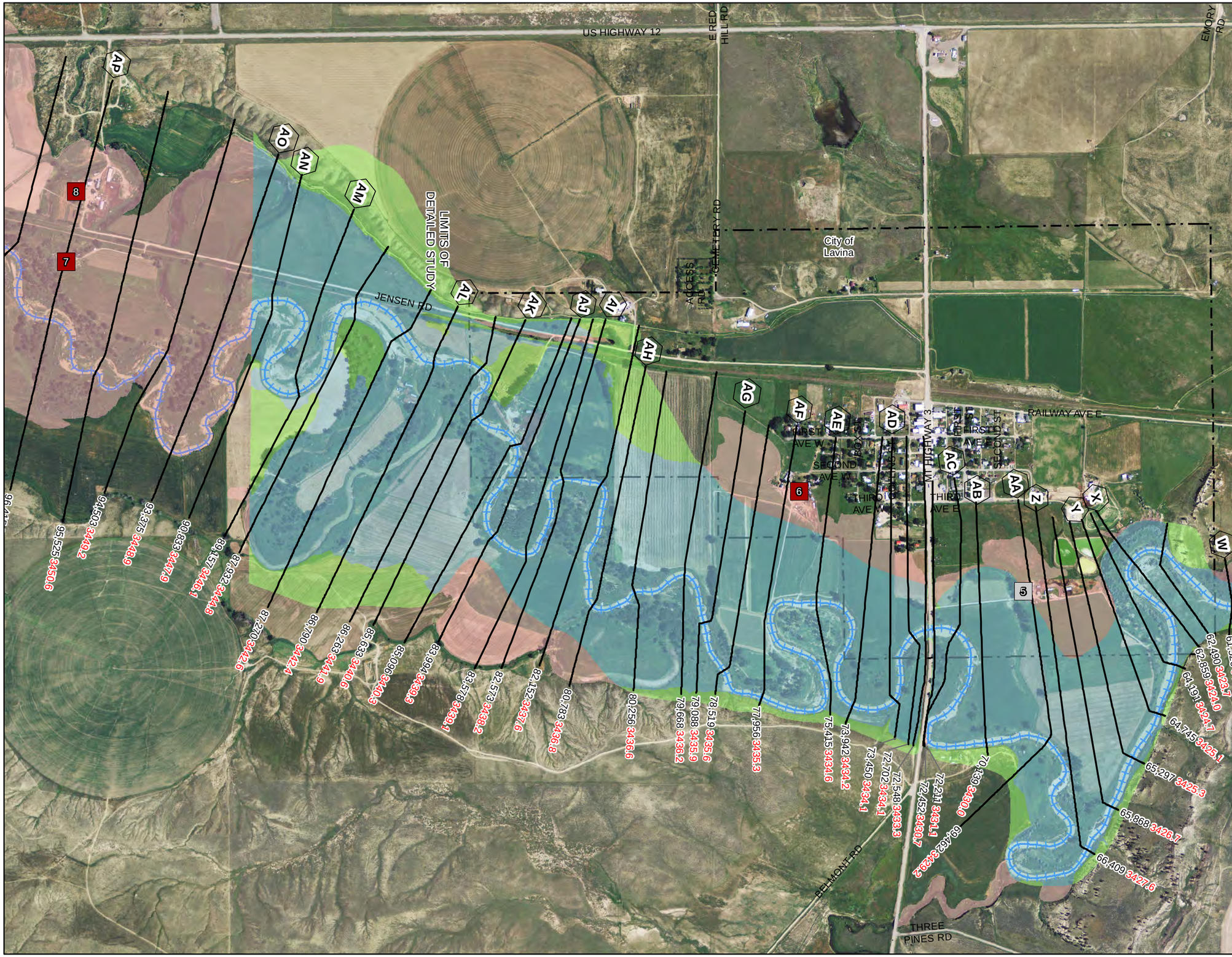
LOCATOR MAP



Musselshell River Map 3 of 14



CHANGES SINCE LAST FIRM - PROPOSED STRUCTURE CHANGES FOR FLOODPLAIN

January 13, 2017

LEGEND

- Proposed Floodplain - Increase
- Proposed Floodplain - Decrease
- Proposed Floodplain - No Change
- 1 Structure - In Increase Area
- 1 Structure - In Decrease Area
- 1 Structure - In No Change Area

Labels

- A Cross Section Letter — 79,726 River Station
- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

0 500 1,000 1,500 Feet

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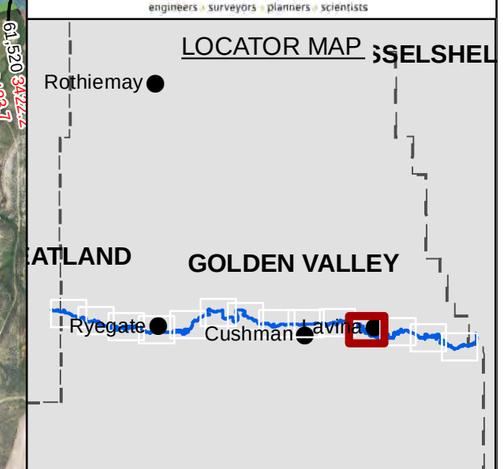
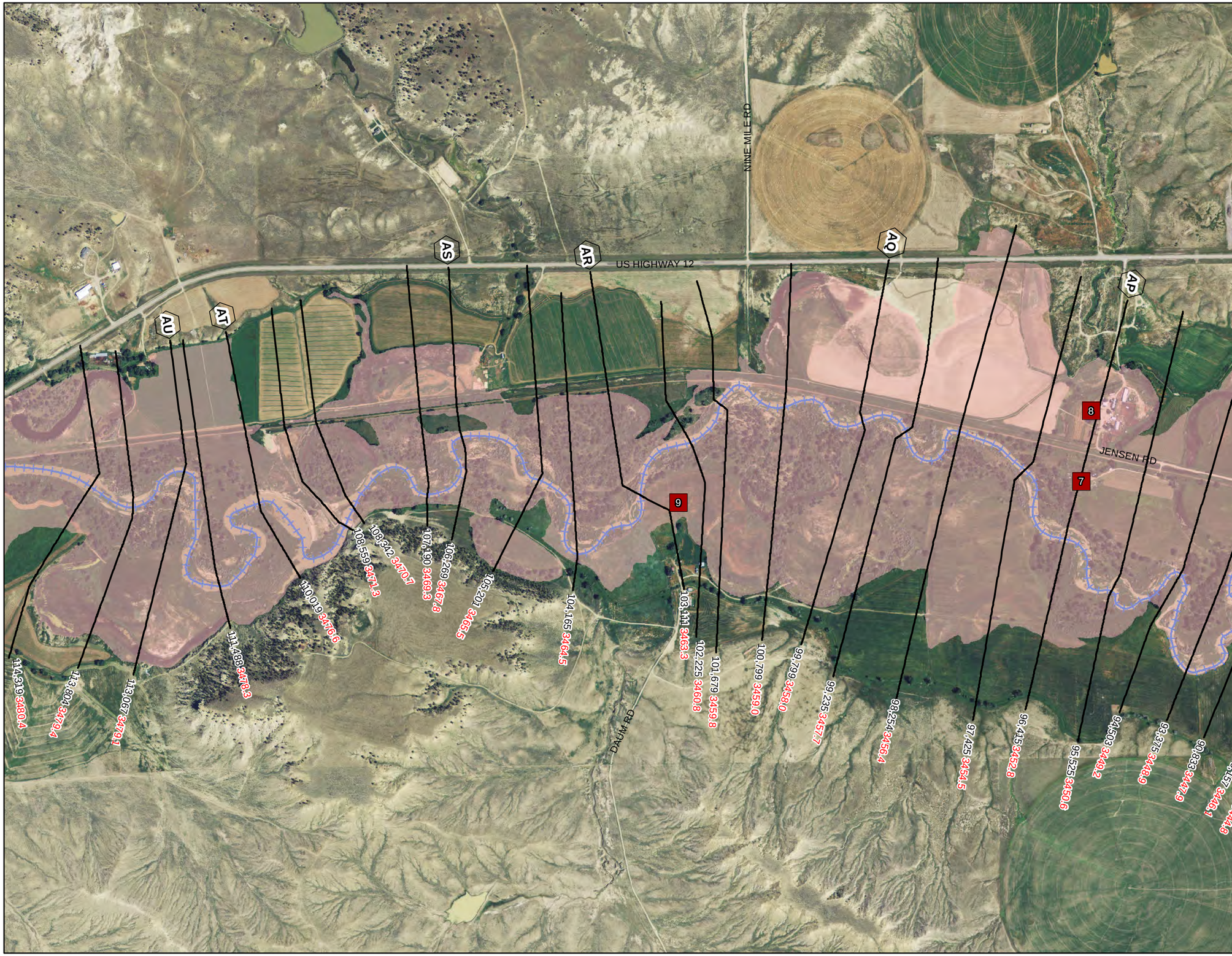
LOCATOR MAP



Musselshell River Map 4 of 14



CHANGES SINCE LAST FIRM - PROPOSED STRUCTURE CHANGES FOR FLOODPLAIN

January 13, 2017

LEGEND

- Proposed Floodplain - Increase
- Proposed Floodplain - Decrease
- Proposed Floodplain - No Change
- 1 Structure - In Increase Area
- 1 Structure - In Decrease Area
- 1 Structure - In No Change Area

Labels

- A Cross Section Letter — 79,726 River Station
- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

0 500 1,000 1,500 Feet

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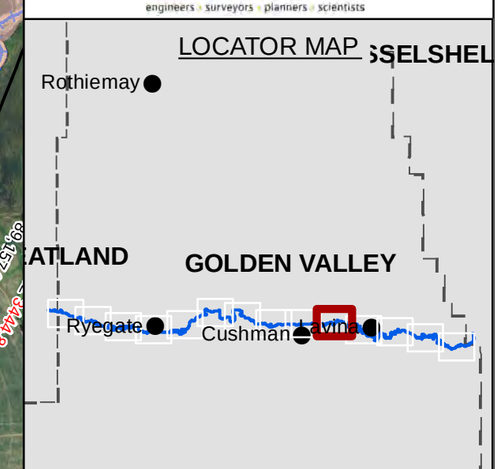
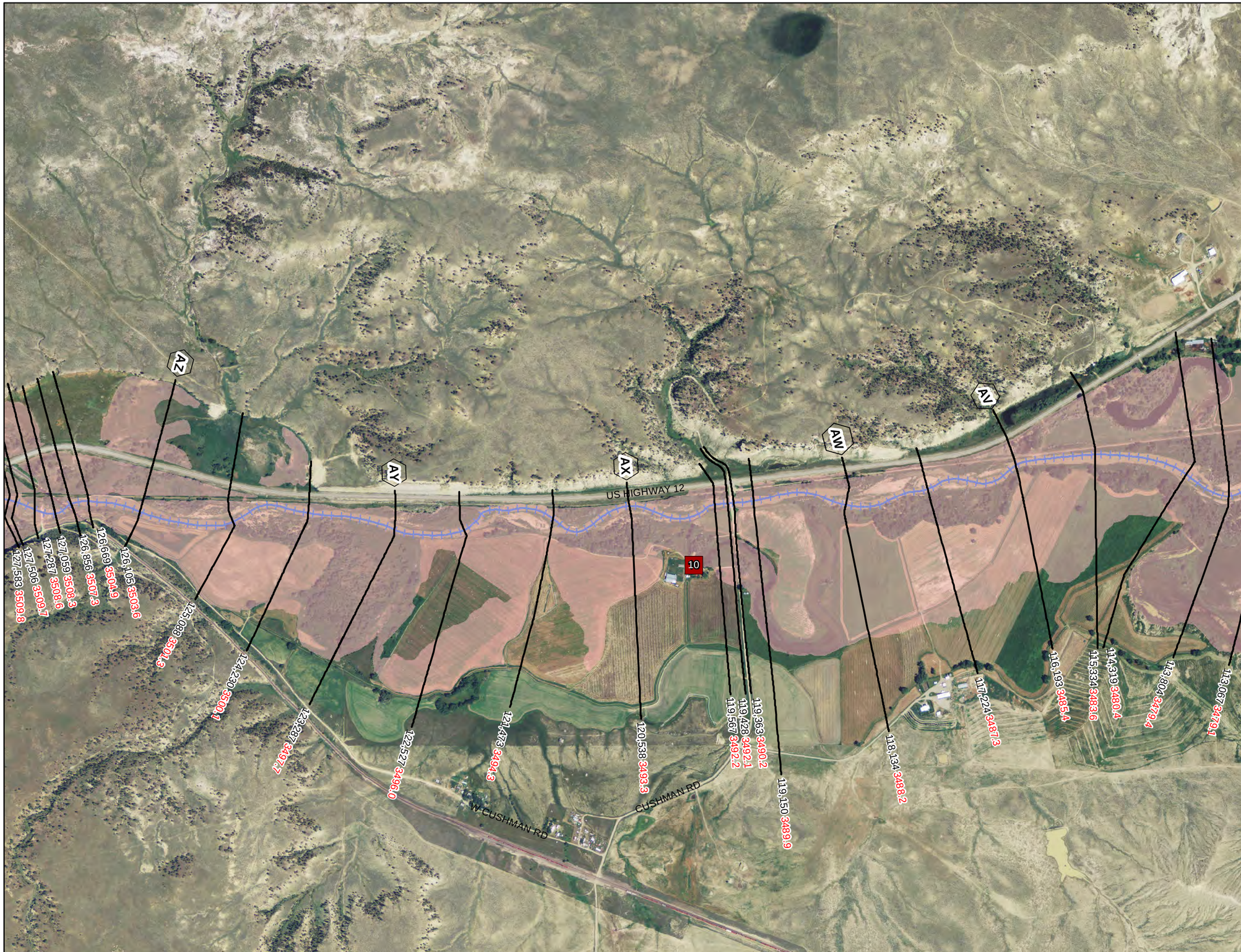
LOCATOR MAP



Musselshell River Map 5 of 14



CHANGES SINCE LAST FIRM - PROPOSED STRUCTURE CHANGES FOR FLOODPLAIN

January 13, 2017

LEGEND

- Proposed Floodplain - Increase
- Proposed Floodplain - Decrease
- Proposed Floodplain - No Change
- 1 Structure - In Increase Area
- 1 Structure - In Decrease Area
- 1 Structure - In No Change Area

Labels

- A Cross Section Letter 79,726 River Station
- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

0 500 1,000 1,500 Feet

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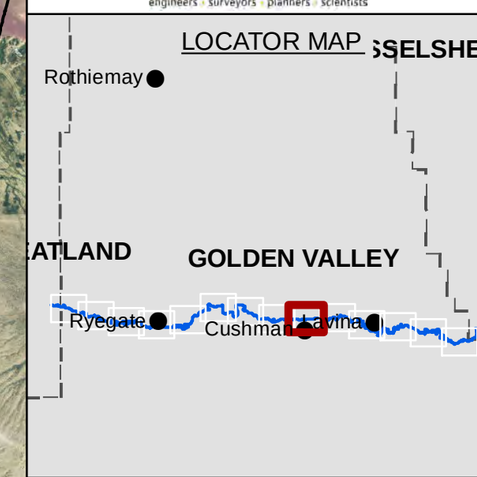
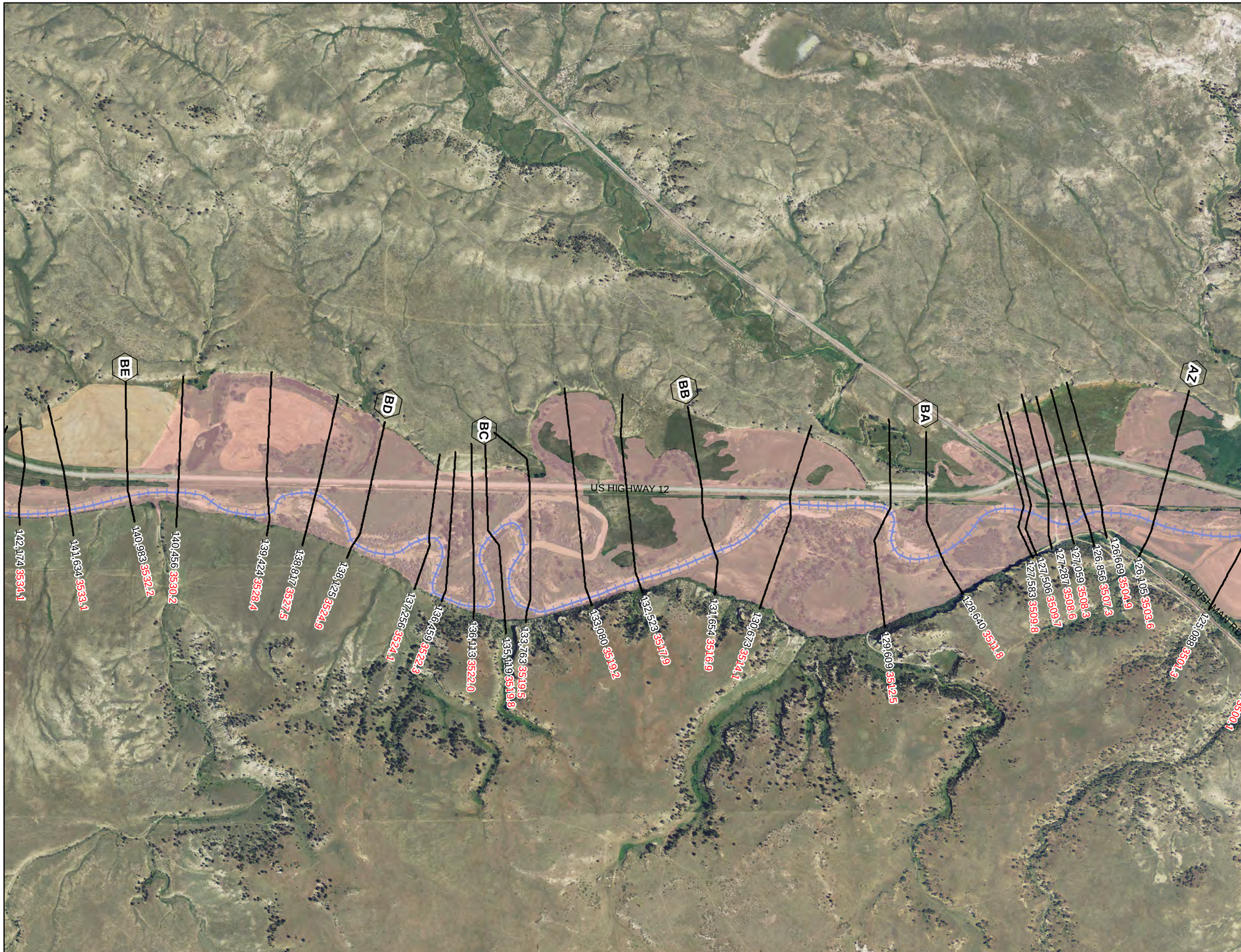
LOCATOR MAP



Musselshell River Map 6 of 14



CHANGES SINCE LAST FIRM - PROPOSED STRUCTURE CHANGES FOR FLOODPLAIN

January 13, 2017

LEGEND

- Proposed Floodplain - Increase
- Proposed Floodplain - Decrease
- Proposed Floodplain - No Change
- 1 Structure - In Increase Area
- 1 Structure - In Decrease Area
- 1 Structure - In No Change Area

Labels

- A Cross Section Letter — 79,726 River Station
- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

0 500 1,000 1,500 Feet

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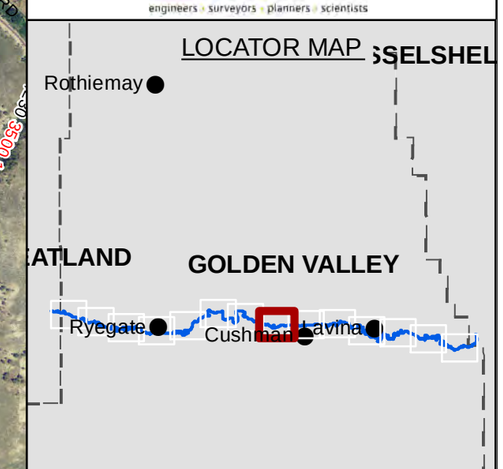
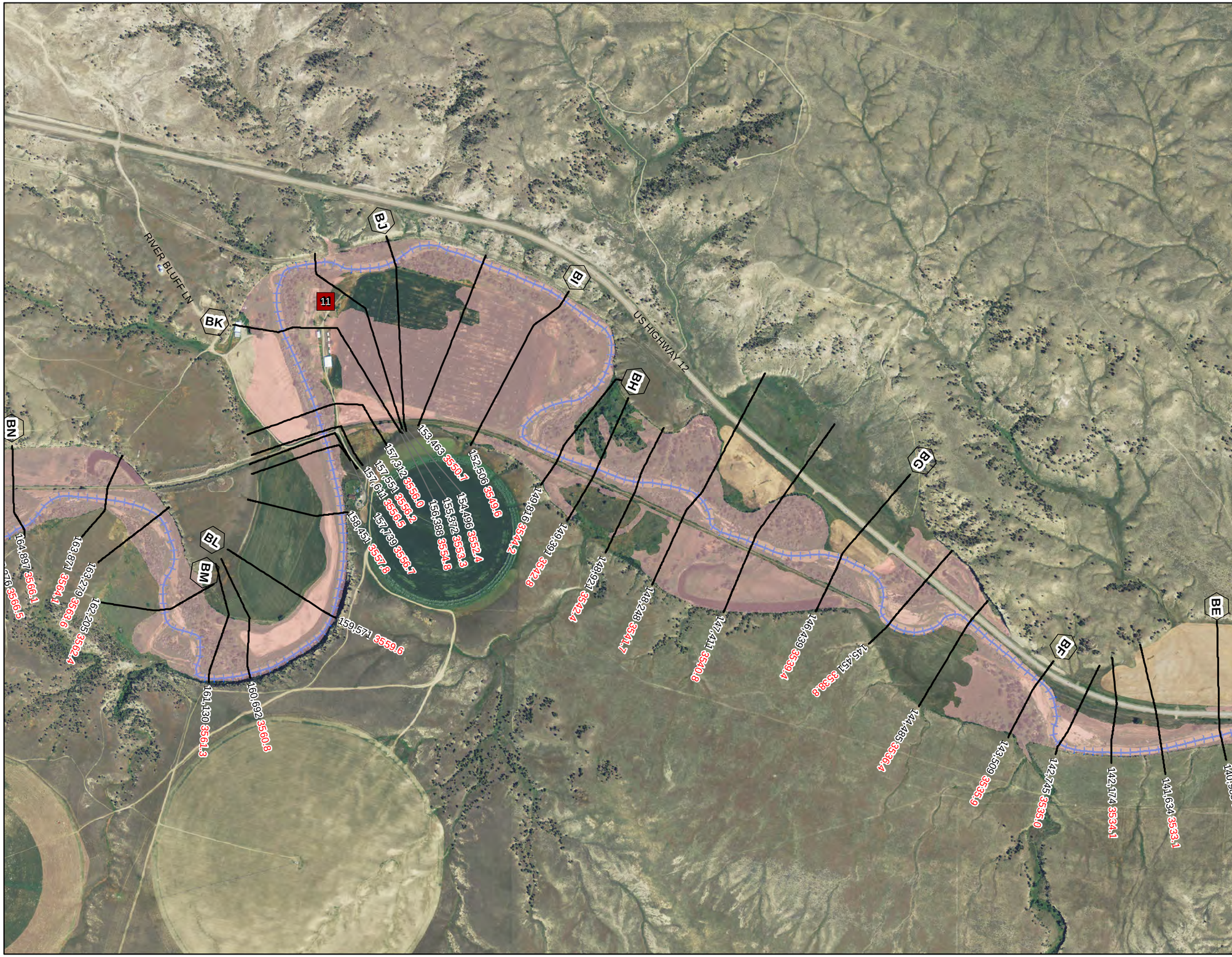


Musselshell River Map 7 of 14



CHANGES SINCE LAST FIRM - PROPOSED STRUCTURE CHANGES FOR FLOODPLAIN

January 13, 2017

LEGEND

- Proposed Floodplain - Increase
- Proposed Floodplain - Decrease
- Proposed Floodplain - No Change
- 1 Structure - In Increase Area
- 1 Structure - In Decrease Area
- 1 Structure - In No Change Area

Labels

- A Cross Section Letter 79,726 River Station
- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

0 500 1,000 1,500 Feet

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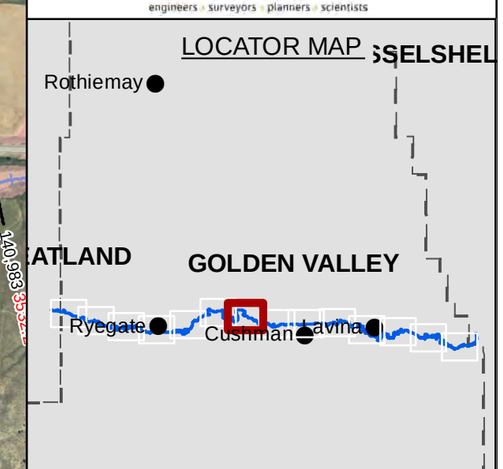
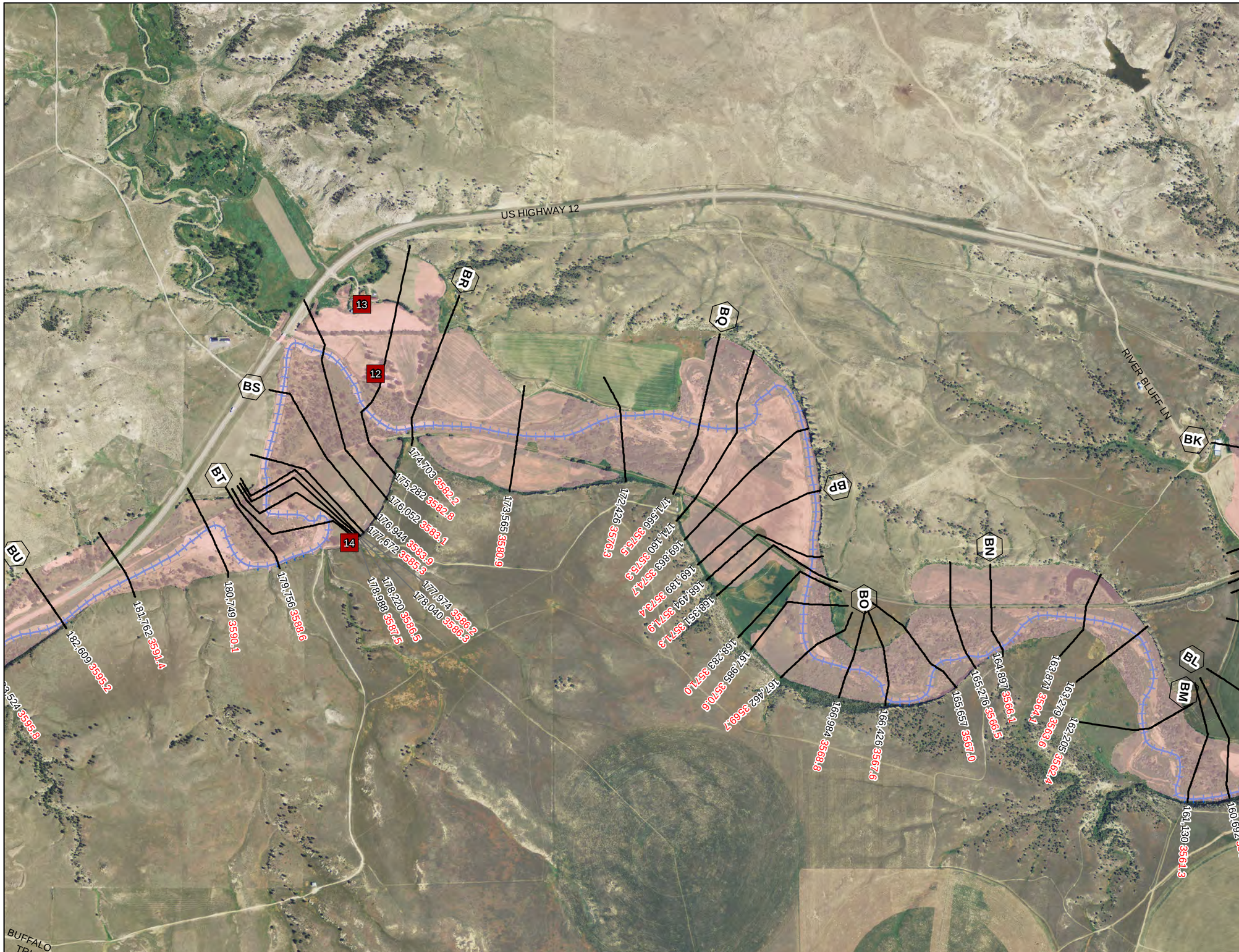
LOCATOR MAP



Musselshell River Map 8 of 14



CHANGES SINCE LAST FIRM - PROPOSED STRUCTURE CHANGES FOR FLOODPLAIN

January 13, 2017

LEGEND

- Proposed Floodplain - Increase
- Proposed Floodplain - Decrease
- Proposed Floodplain - No Change
- 1 Structure - In Increase Area
- 1 Structure - In Decrease Area
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Labels

- A Cross Section Letter — 79,726 River Station
- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

0 500 1,000 1,500 Feet

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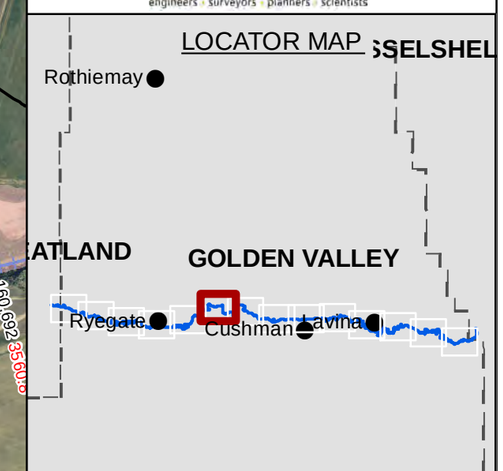
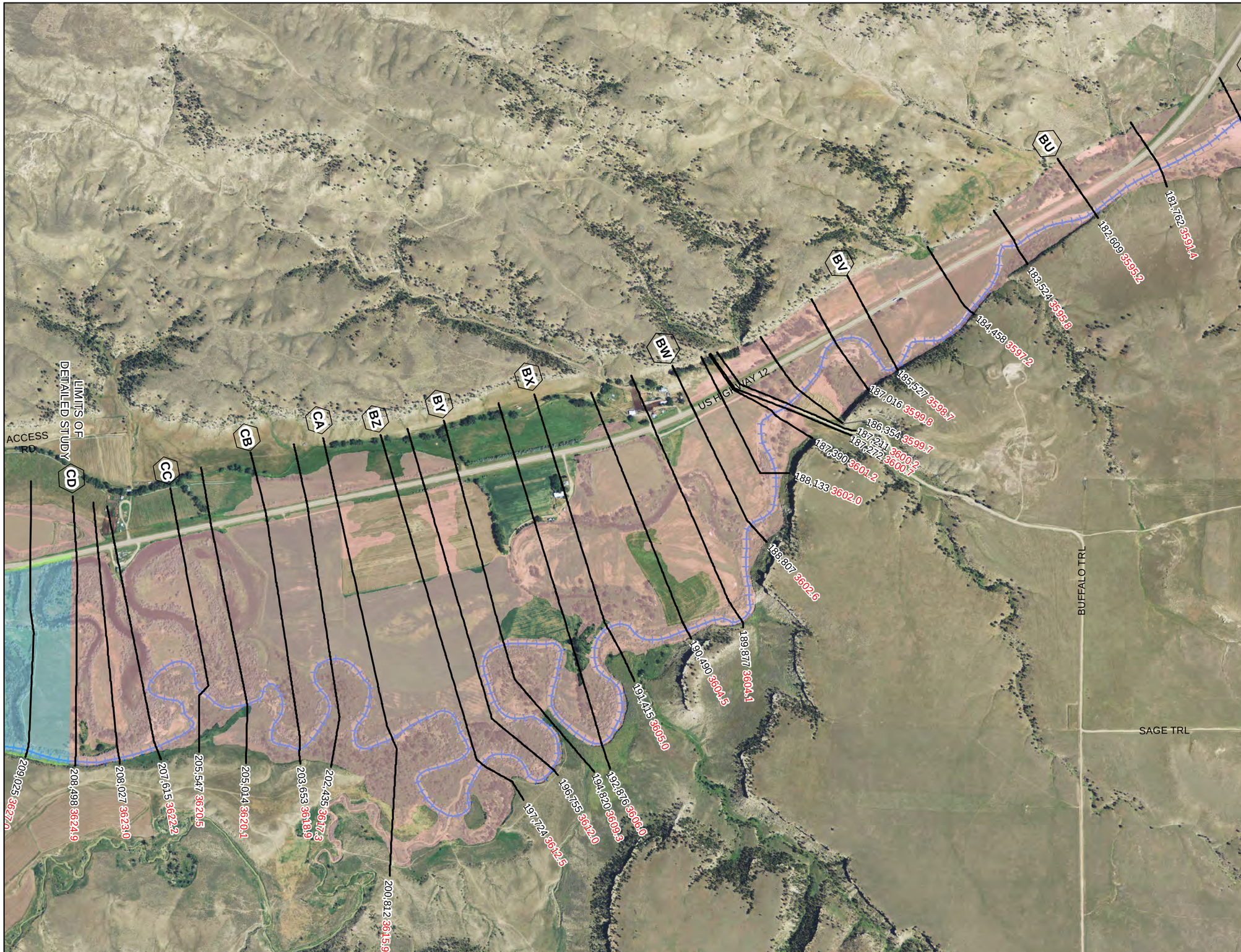
LOCATOR MAP



Musselshell River Map 9 of 14



CHANGES SINCE LAST FIRM - PROPOSED STRUCTURE CHANGES FOR FLOODPLAIN

January 13, 2017

LEGEND

- Proposed Floodplain - Increase
- Proposed Floodplain - Decrease
- Proposed Floodplain - No Change
- Structure - In Increase Area
- Structure - In Decrease Area
- Structure - In No Change Area

Labels

- A Cross Section Letter — 79,726 River Station
- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

0 500 1,000 1,500 Feet

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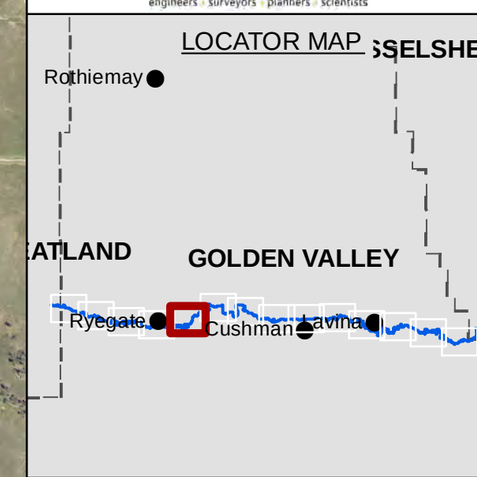
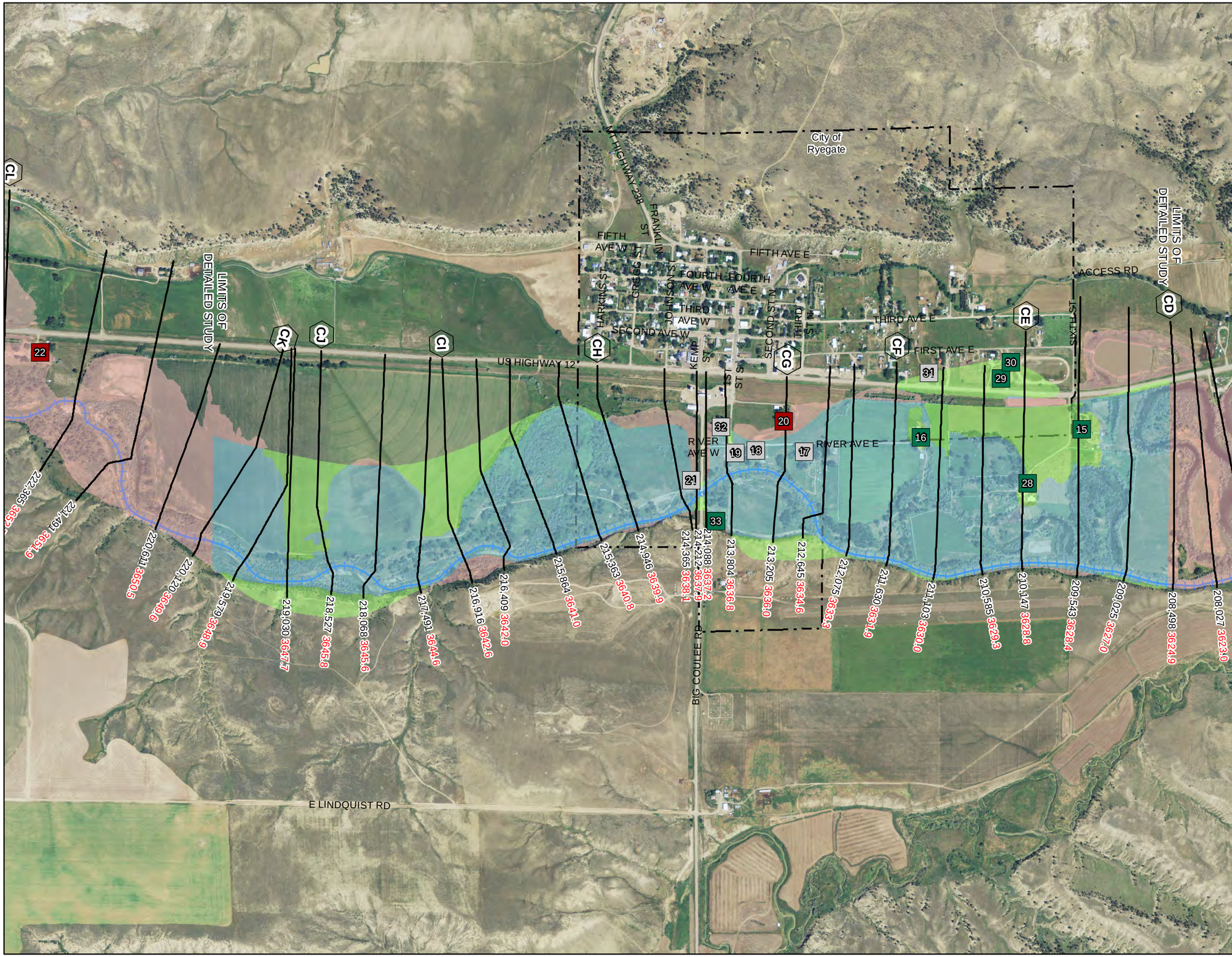
LOCATOR MAP



Musselshell River Map 10 of 14

CHANGES SINCE LAST FIRM - PROPOSED STRUCTURE CHANGES FOR FLOODPLAIN

January 13, 2017



LEGEND

- Proposed Floodplain - Increase
- Proposed Floodplain - Decrease
- Proposed Floodplain - No Change
- Structure - In Increase Area
- Structure - In Decrease Area
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Labels

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- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

0 500 1,000 1,500 Feet

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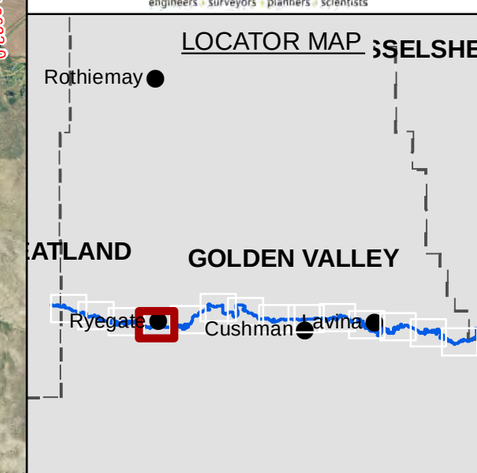
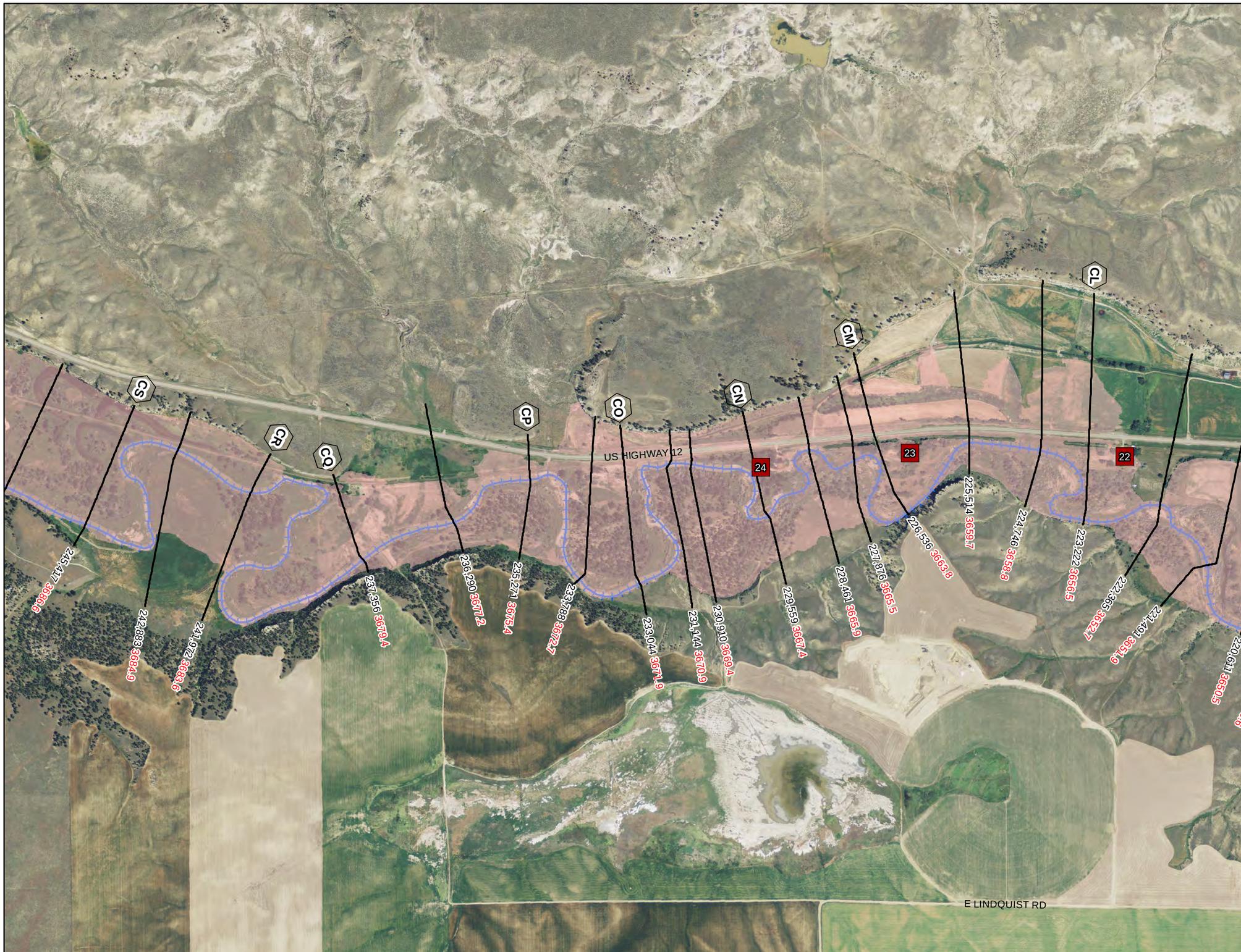
LOCATOR MAP





CHANGES SINCE LAST FIRM - PROPOSED STRUCTURE CHANGES FOR FLOODPLAIN

January 13, 2017

LEGEND

- Proposed Floodplain - Increase
- Proposed Floodplain - Decrease
- Proposed Floodplain - No Change
- 1 Structure - In Increase Area
- 1 Structure - In Decrease Area
- 1 Structure - In No Change Area

Labels

- A Cross Section Letter 79,726 River Station
- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

0 500 1,000 1,500 Feet

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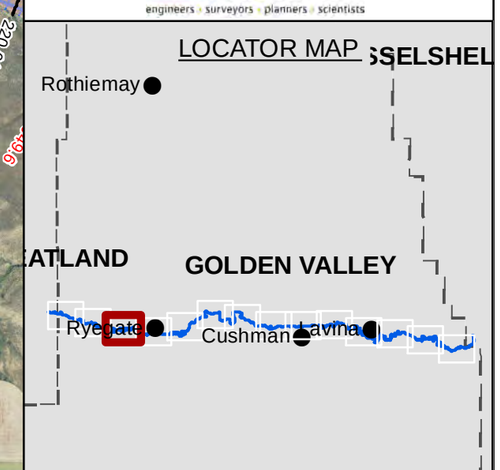
LOCATOR MAP



Musselshell River Map 12 of 14

CHANGES SINCE LAST FIRM - PROPOSED STRUCTURE CHANGES FOR FLOODPLAIN

January 13, 2017

LEGEND

- Proposed Floodplain - Increase
- Proposed Floodplain - Decrease
- Proposed Floodplain - No Change
- Structure - In Increase Area
- Structure - In Decrease Area
- Structure - In No Change Area

Labels

- A Cross Section Letter — 79,726 River Station
- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

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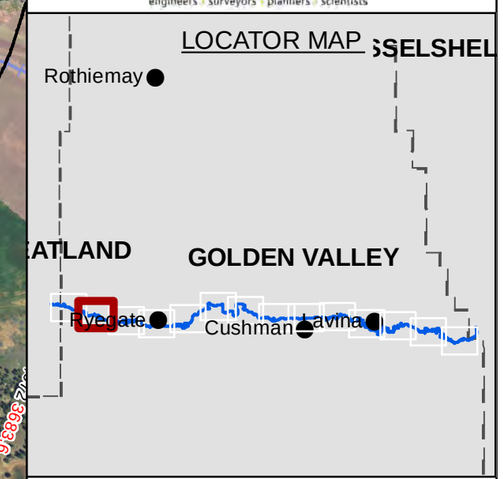
LOCATOR MAP



Musselshell River Map 13 of 14

CHANGES SINCE LAST FIRM - PROPOSED STRUCTURE CHANGES FOR FLOODPLAIN

January 13, 2017

LEGEND

- Proposed Floodplain - Increase
- Proposed Floodplain - Decrease
- Proposed Floodplain - No Change
- 1 Structure - In Increase Area
- 1 Structure - In Decrease Area
- 1 Structure - In No Change Area

Labels

- A Cross Section Letter — 79,726 River Station
- 4,700.0 Water Surface Elevation
- 100 Feet Along Profile Baseline

0 500 1,000 1,500 Feet

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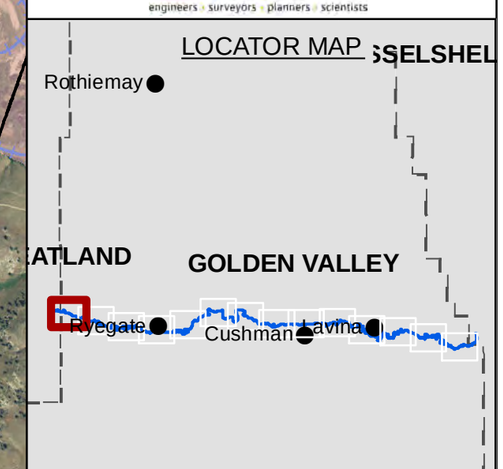
LOCATOR MAP



Musselshell River Map 14 of 14